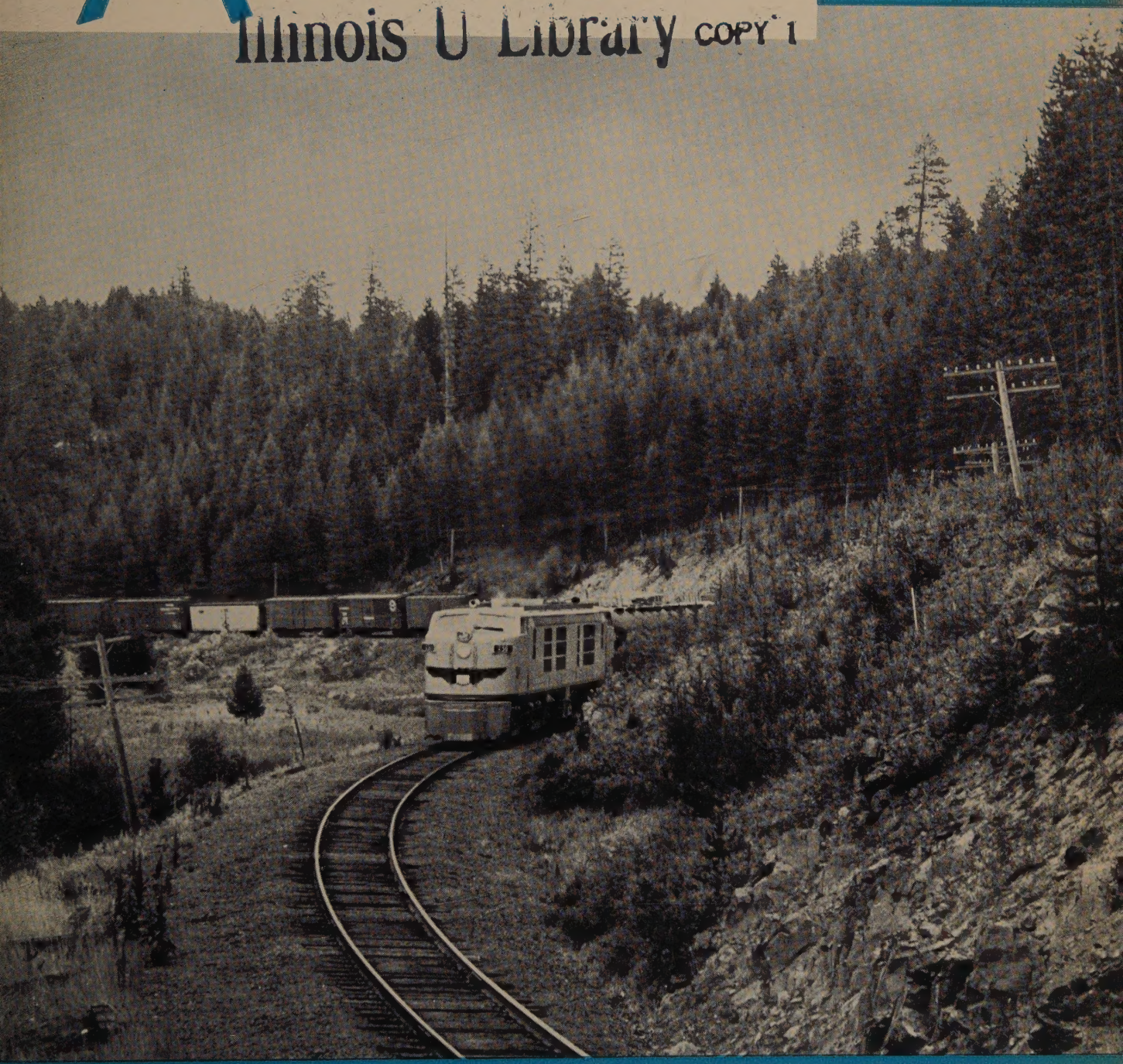
LUME 53 NUMBER 12 . . ONE YEAR FOUR DOLLARS

GENERAL ELECTRIC REVIEW

Illinois U Library COPY 1

TABLE OF CONTENTS
Page Three



ELECTRICAL AND ALLIED DEVELOPMENTS OF 1949

January, 1950

C-D CAPACITORS MAY *LOOK* LIKE OTHERS, BUT...

SUPERFICIALLY, they may LOOK alike. But men like yourself don't judge performance by looks. You want to know how well they're *made*. And, equally important, *who* makes them.

The Cornell-Dubilier name on a capacitor does *more* than identify the product's maker. It identifies the capacitor as a product of 40 years' *specialized* capacitor experience, and a product which is *world famous*.

You are safe in joining the leading engineers who specify C-D.

C-D PAPER CAPACITORS

Typical of the line of C-D capacitors is the complete listing of capacitors made in accordance with joint Army and Navy specification JAN-C-25. These are completely covered in Cornell-Dubilier catalog #400 which is now available.

Cornell-Dubilier engineers will welcome the opportunity of assisting you with your capacitor problems.

Cornell-Dubilier Electric Corporation, Dept. L-10. South Plainfield, New Jersey. Other plants in New Bedford, Brookline and Worcester, Mass.; Providence, Rhode Island; Indianapolis, Ind., and subsidiary, The Radiart Corp., Cleveland, Ohio.

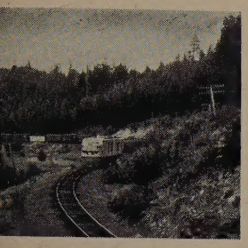
1910 1950
Reg. U. S. Pat. Off.

CORNELL-DUBILIER
CONSISTENTLY DEPENDABLE
★ CAPACITORS
★ VIBRATORS
★ ANTENNAS
★ CONVERTERS

C-D Best by Field Test!

GENERAL ELECTRIC REVIEW

JANUARY, 1950
Vol. 53, No. 1



THE COVER

erica's first gas turbine-electric locomotive (an o-GE product) in test service on the Union Pacif- Railroad, hauling a freight train up a 2.2-percent de. In its preliminary tests, this new 4500-hp omotive hauled eighty-five loaded freight cars at eds up to 65 mph. The rating of the power plant vides for a speed of 18.2 mph at a continuous ctive effort of 77,800 lb. This innovation in rail- y power equipment was one of the spectacular velopments in the electrical industry during 1949. *e p. 38.)*

ADVERTISING INDEX

craft-Marine Products, Inc. 58
nco Steel Corp. 62

and & Co., Wm. 72
tish Thomson-Houston Co., Ltd. 56
ish Development Co. 4

nadian General Electric Co., Ltd. 63
re and Co., C.P. . . . . 4th cover
rostat Manufacturing Co., Inc. 67
rnell-Dubilier Electric Corp. . . . . 2d cover

ven Co. 5
al Light Co. of America 63
iver-Harris Co. 65
ison-Swan Electric Co., Ltd. 56

guson Pailin Ltd. 56

neral Electric Co. . . . . 8, 54, 68, 3d cover
nnini and Co., G. M. 64

vi Duty Electric Co. 1
tpoint Electric Appliance Co., Ltd. 56

co Copper Tube & Products, Inc. 60
gersoll-Rand Co. 70
ernational General Electric Co. 66

ria Bros., Inc. 56

llory and Co., Inc., P. R. 9
tron Instrument Co. 58, 67
tropolitan-Vickers Electrical Co., Ltd. 56
tropolitan-Vickers-GRS, Ltd. 56
niature Precision Bearings, Inc. 60

w Departure—Div. General Motors Corp. . . . 53
wton Victor Ltd. 56

mite Manufacturing Co. 6

tsburgh Lectrodryer Corp. 2

ton Can Co., Inc. 55
rron Electronics Co. 71
er Carbon Co. 61
ague Electric Co. 57

mpil Corp. 64

kers Electric Division, Vickers, Inc. 7

st Virginia Pulp & Paper Co. 58

J. S. SMITH, Manager
E. C. SANDERS, Executive Editor
J. E. GLICK, Associate Editor

EDITORIAL CONTENTS

FRONTISPIECE: Power for West Coast's First Hot-Strip Mill . 10

ELECTRICAL & ALLIED DEVELOPMENTS IN 1949 Guy Bartlett 11

RESEARCH 12
Metallurgical Investigations (12); Chemical Attainments (13); Weather Studies (13); Electronic Advances (13); Nuclear and X-ray Tools (13).

TESTING AND MEASURING 14
Testing Equipments (14); Electrical Measurements (14); Mechanical Tests (16); Chemical Tests (16); Timing Devices (17); Optical Equipments (17); Temperature (17); Industrial X-rays (17).

POWER 18
Power Generation (18); Transformers (19); Transmission (20); Switchgear (20); Unit Equipments (21); Capacitors (21); Arresters, Cutouts and Fuses (22); Voltage Regulators (22); Cable (23); Carrier Current (23); Rectifiers and Chargers (23).

INDUSTRY 24
Motors (24); Control (26); Industrial Heating (27); Welding (28); Power Electronics (28); Water and Sewage (29); Coal Handling (29); Mining (30); Lumber (30); Paper (30); Textile (31); Machine Tools (31); Steel and Other Metals (32); Farm Industry (34).

TRANSPORTATION 35
Aviation (35); Marine (37); Land Transportation (38).

ELECTROMEDICAL 40

ELECTRONICS 41
Transmitters (41); Receivers (42); Specialties and Instruments (43); Electron Tubes (43).

LIGHTING 44

AIR CONDITIONING 47

APPLIANCES 48

CONSTRUCTION MATERIALS 50

CHEMICAL AND METALLURGICAL 51
Metallurgical Products (51); Silicones (52); Resins and Plastics (52); Plastics Applications (52).

DEPARTMENTS:

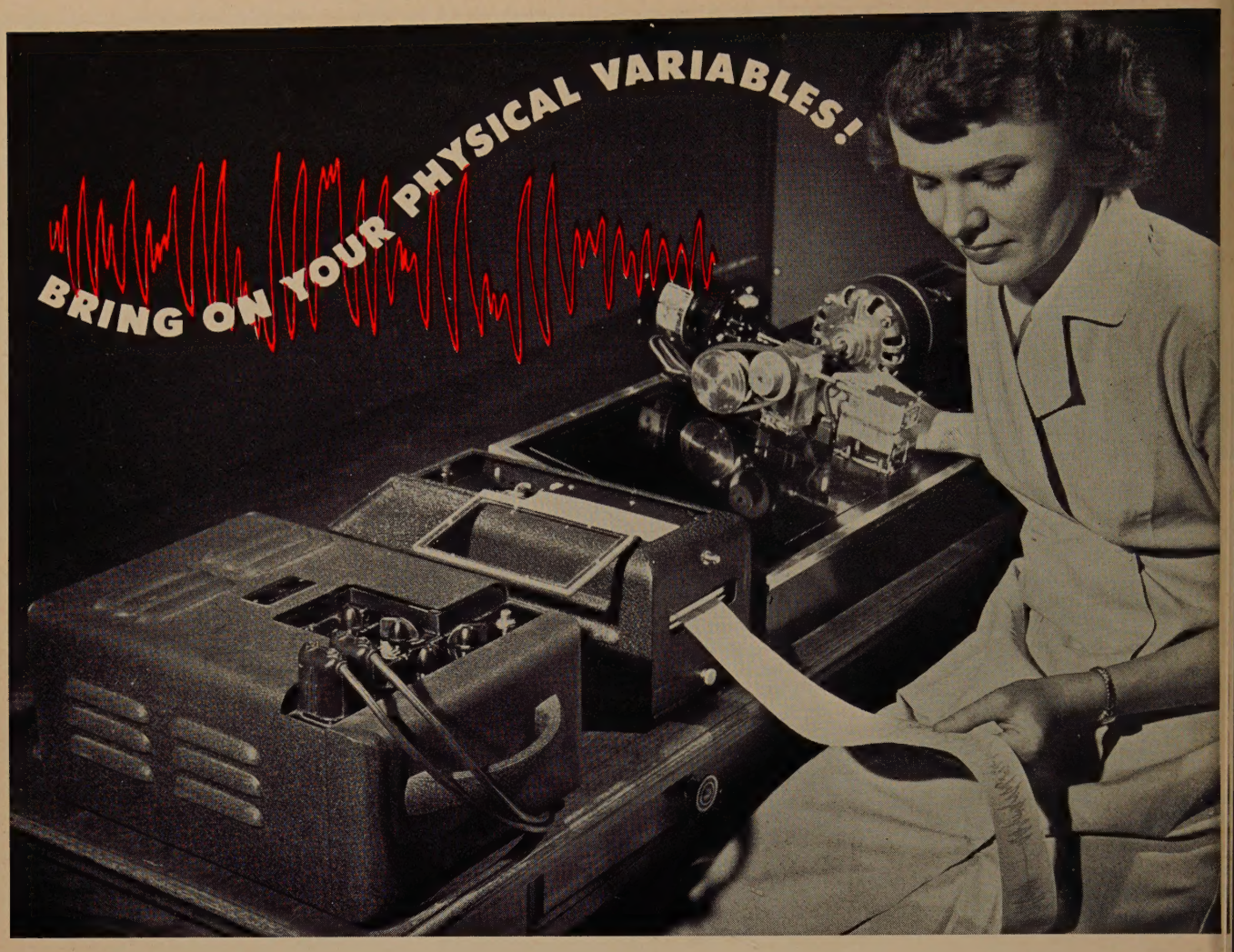
High Lights and Side Lights . 55
New Products . . . 59
Trade Literature . . 60
Book Reviews . . 63
Library Notes . . 67

INDEXED BY INDUSTRIAL ARTS INDEX, ENGINEERING INDEX, SCIENCE ABSTRACTS

Editorial Advisory Board: H. A. WINNE, Chairman • H. L. ANDREWS
Dr. W. R. G. BAKER • W. C. BROWN • H. V. ERBEN

CIRCULATION DEPARTMENT: General Electric Review, Schenectady 5, New York.
SUBSCRIPTION RATES: *Payable in advance.* United States and Possessions, and countries in Pan-American Postal Union, one year $4.00, two years $6.50, three years $8.00. Canada, add $1.00 to above rates. Other foreign countries, add $2.00. Public and college libraries, professors, and enrolled students deduct $1.00 from above rates. SINGLE COPY 40¢.
CHANGE OF ADDRESS: Give old and new addresses. Notices received before the fifteenth of the month will be effective with the next issue.
ADVERTISING DEPARTMENT: General Electric Review, Schenectady 5, New York.

Entered as second-class matter, March 26, 1912, at the post office at Schenectady, N. Y., under Act of March 3, 1879. Published monthly by General Electric Company, 1 River Road, Schenectady 5, N. Y. Printed in U. S. A. *Copyright 1950 by General Electric Company.*



You can solve many problems and *prove* results with the New BRUSH "Universal Analyzer"

● Brush announces an important addition to its complete line of Recording Analyzers. The New Brush "Universal Analyzer" gives instantaneous, accurate recording of a wide variety of physical variables such as strain, pressure, acceleration, torque, force, temperature, displacement and vibration . . . to help you solve a host of research, development and production problems . . . and to give you definite *proof* of results!

This new Brush Analyzer consists of a Carrier Type Bridge Amplifier and Direct-Inking Oscillograph . . . is used in conjunction with conventional primary pickup elements. With proper calibration resistors, these ink-on-paper records of the Brush "Universal Analyzer" can be interpreted immediately and easily in any desired units of physical measurement.

Write today for complete details on this new Brush aid for accurate measurements and *proven* results.

THE *Brush* DEVELOPMENT COMPANY

3405 Perkins Avenue, Cleveland 14, Ohio, U.S.A.

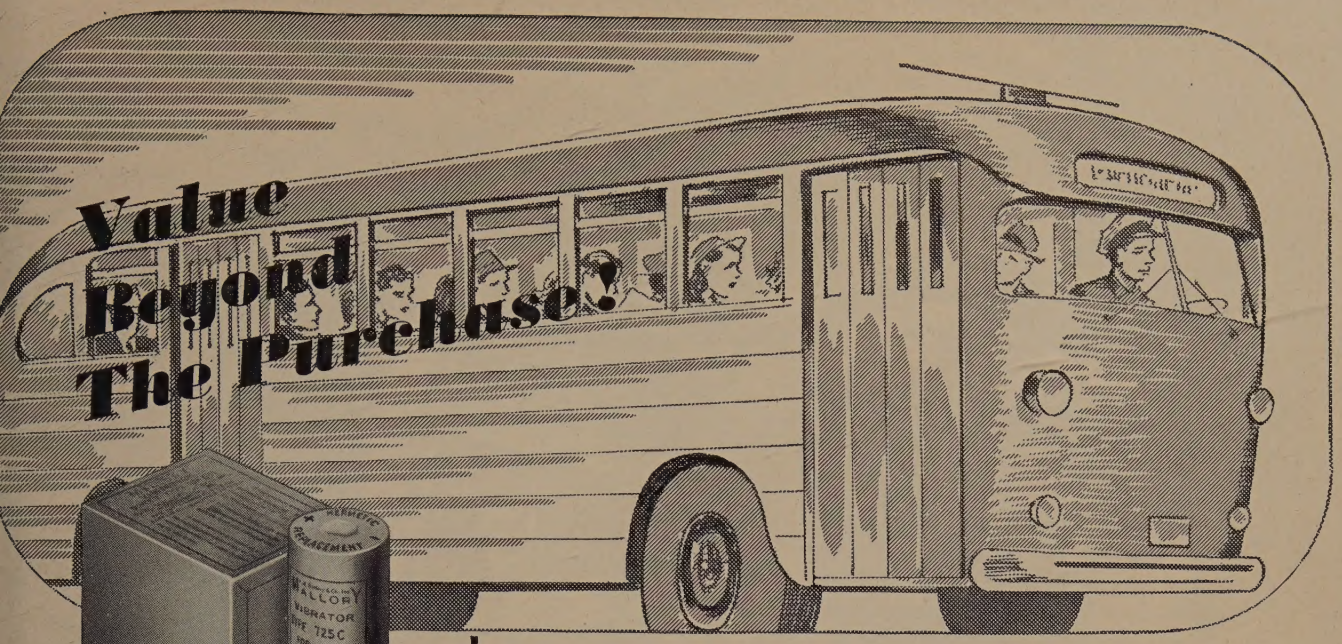
Canadian Representatives: A. C. Wickman (Canada) Ltd., P. O. Box 9, Station N, Toronto 14, Ontario

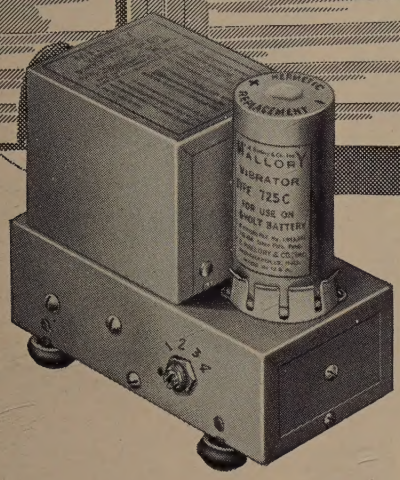
STRAIN
VIBRATION
VOLTAGE
PRESSURE
SURFACE
CONTOUR
ETC.

Put it in writing with a

BRUSH RECORDING ANALYZER

STRAIN ANALYZERS • SURFACE ANALYZERS • CONTOUR ANALYZERS • UNIVERSAL ANALYZERS • UNIFORMITY ANALYZERS





MALLORY VIBRATORS

Mallory Vibrators and Vibrapack power supplies are based on exclusive design and manufacturing methods that assure long, trouble-free service. Send the details of your application. Get Mallory's recommendation on the Vibrator or Vibrapack power supply best suited to your needs.

Mallory Vibrapacks* Replace Costly Power Supply System *Effect Tremendous Savings!*

In one typical case, a simple and inexpensive circuit modification, developed by Mallory, made it possible for a manufacturer of mobile radio receivers to substitute Vibrapacks for a costly and less efficient power supply system. The conversion saved this Mallory customer $40,000 in the first year! In addition, thousands of dollars are being saved in maintenance costs. Servicing the old system required hours of labor . . . the new one requires only occasional replacement of the vibrator.

When you buy Mallory vibrator equipment you benefit by a winning combination of dependability, economical performance and creative engineering.

That's value beyond the purchase!

And whether your problem is electronic or metallurgical, what Mallory has done for others can be done for you!

Vibrators and Vibrapack Power Supplies

P. R. MALLORY & CO., Inc.

MALLORY

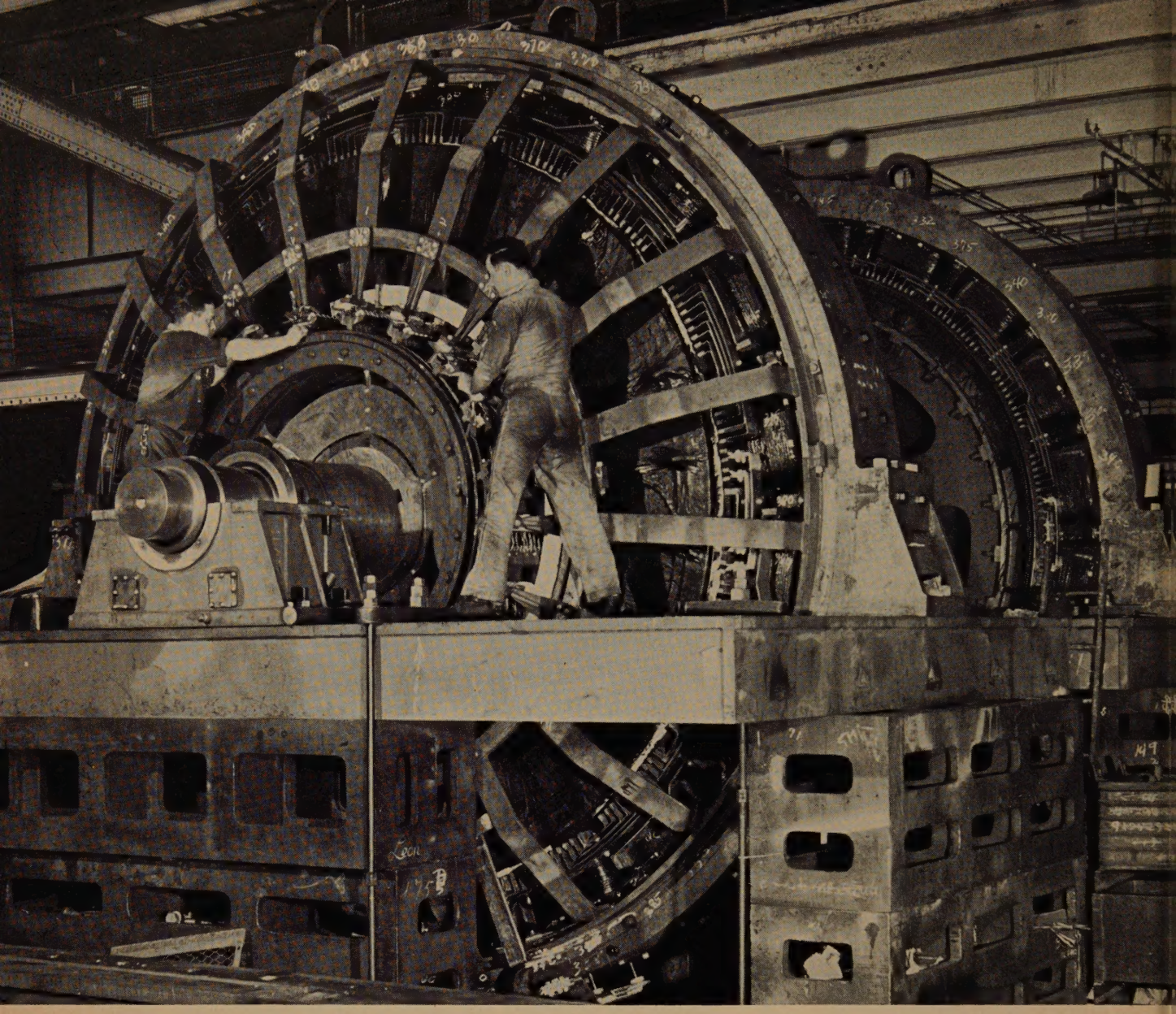
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors	Contacts
Controls	Resistors
Rectifiers	Vibrators
Special Switches	Power Supplies

Resistance Welding Materials

**Reg. U.S. Pat. Off.*



POWER FOR WEST COAST'S FIRST HOT-STRIP MILL

Two 5000-hp motors for driving the finishing stands of a continuous 86-in. hot-strip mill. Adjustable-voltage power for their operation is supplied by two mercury-arc rectifiers with a newly developed amplistat regulating system. The motors are here shown being prepared for test. (*See p. 32*)

ELECTRICAL AND ALLIED DEVELOPMENTS DURING 1949

Guy Bartlett

By GUY BARTLETT
General Electric Company, Schenectady, N. Y.

BACK of the new products of 1949 is a never-ceasing search for added knowledge, not only of electricity, magnetism, and insulation, but bout the materials mechanically entering construction -in the fields of metallurgy, plastics, ceramics, oils, lid and liquid insulations. Lightning and high-voltage henomena, magnetic fields, radio-wave propagation, as and liquid flow all enter the picture. So do mechan-al analyzers, swift and accurate in solving intricate ngineering problems which scientists and engineers eed answered. Then, too, there are those continuing, tensified, fundamental investigations of the molecule, ie atom, the electron, and the other particles so em-hasized by the newer, fast-growing branches of the ectrical industry as exemplified by electronics and ucleonics.

Progress of the electrical industry in 1949 was partic-arly significant in many fields. In power generation, r instance, there were the installation and operation the first stationary gas turbine-generator, and of ree mercury unit power plants.

Further advances in the design of electric equipment etter able to withstand damage from lightning, and ith the objective of lower cost, will be attained in a w high-voltage engineering laboratory.

Power-transformer production at Pittsfield was the rgest in its history. Today it appears the only limiting ctor as to maximum rating is transportation facilities.

Outdoor switching units for 230,000-volt service were oduced as package units. They interrupt 10,000,000 va in 1/20 second.

There was an increased demand for adjustable-speed ives, and integrated, factory-assembled generator, otor, and control in one case, ready for connection. se of an alnico permanent magnet in a fractional-rsepower motor greatly improved operating charac-ristics and considerably reduced motor size.

Galvanized steel produced in the new continuous nealing and dry-pickling furnace can be bent, rolled, nd to some extent drawn without cracking or flaking e zinc.

An electronic shuttle detector for large felt looms ops the loom, on faulty shuttle flight, before the fabric damaged; its use effects increased loom speed.

An optical contour-following system causes a machine ol to follow a fine-line drawing with a machining curacy of one mil.

The amplistat, a self-saturated magnetic amplifier without tubes or moving parts, was used in conjunction with the amplidyne to maintain steel strip at a predetermined level in the pickling tanks of a new 66-inch pickling line, and also to hold tension on the winding reel of the world's fastest cold-strip mill.

A Boeing XB-47 Stratojet bomber with six G-E J-35 jet engines set a coast-to-coast speed record of 607 mph during the year. The plane is to be equipped with the even more powerful J-47 turbojet, giving 25 percent more total power.

Steam at higher temperature, hence greater economy, was used for the propulsion geared turbines of a number of tankers and supertankers. America's first gas-turbine-driven locomotive went into road service.

New television receiver circuits provided automatic sound tuning and minimized electric disturbances.

Pilot installations of heat pumps, for cooling and heating, were made in selected areas throughout the country. The air is the primary heat source, with water or ground coils supplementing some installations.

Lower-cost products were the trend in appliance developments. A portable dishwasher, for example, does the same job as the stationary type but offers a considerable saving in installation costs.

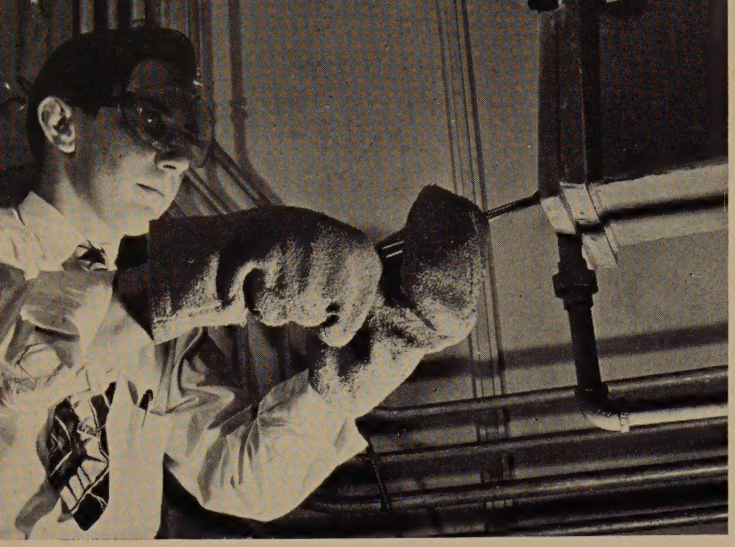
Remote control of lighting, heating, ventilating, and similar equipments is provided by a self-contained utility unit.

Among new equipments were a beta-ray gage for paper, rubber, plastics, and textile measurements; a recording turbidimeter for water, sewage, and chemical plants; and a high-precision tachometer measuring speeds of rotation up to 15,000 rpm.

Laboratory investigations of metals and alloys were both extensive and intensive; it has become possible to design materials to have required properties at high temperatures.

The Knolls Atomic Power Laboratory will be in full use early in 1950, in studies of nuclear energy for the production of useful power. Construction is about to start on a developmental power plant using a nuclear reactor as the energy source.

This review of electrical and allied developments of 1949 covers only some of the progress recorded by General Electric and its affiliated companies, but it does indicate the progress of the industry as a whole.



Studies of transformations in metals, rates of reaction, and the factors involved in heat-treatment require careful manipulation of the specimen during heat-treatment. Here a sample is being removed from the hydrogen furnace

RESEARCH

METALLURGICAL INVESTIGATIONS

DESIGNERS of power-generating equipment—steam and gas turbines, jet engines, nuclear energy plants—could most advantageously use new alloys for higher temperatures, higher pressures. Other designers similarly need alloys for extremely low-temperature applications. All of them seek more information about their metals and alloys—information that the science of metallurgy must supply.

Exploration of the mechanical properties of several thousand alloys, and increased understanding of the factors controlling the deformation and fracture of metals made it possible to design materials with required properties up to about 1500 F. Alloys consisting largely of nickel, chromium, cobalt, and iron were designed to have certain definite combinations of properties; examination shows them to have approximately the predicted values.

Creep Recovery . . . *and Liquid Metals*

Deformation occurring during the creep of metals at high temperatures is ordinarily thought of as permanent. Recent experiments in the Research Laboratory at Schenectady showed, however, that much of this deformation is temporary—that the deformation is recovered when the load is removed and when the metal is maintained at the elevated temperature.

A broad research showed that not only metals with complicated structures, such as gallium or mercury, but also metals with simple structures—copper, gold, silver, or palladium—may exhibit significant supercooling. Molten copper, for instance, can be chilled 236 C below its melting temperature before it solidifies; tin 110 C, gallium 76 C, lead 80 C, and mercury 46 C.

Results indicate that ordinary solidification, only a few degrees below the melting point, is caused by impurities in the liquid metal. This knowledge may be extremely important to the future development of casting techniques.

Diffusion of Metals . . . *and Low Temperature*

Use of radioactive isotopes was applied to study of rate of diffusion of metals, particularly through the metal grain and along the grain boundaries. At low temperatures, the rate of self-diffusion of silver was found to be higher along grain boundaries than through the grains. At high temperatures, however, diffusion through metal grains was so rapid that grain-boundary diffusion is unimportant.

Liquid helium and liquid hydrogen have been successfully produced in the Low-temperature Laboratory at The Knolls. These materials will be used in the study of electrical, mechanical, and magnetic properties of metals and alloys.

Refractory Melting . . . *and Tensile Tests*

Special melting units were provided, each employing arc-melting in a water-cooled copper crucible with vacuum, or argon or helium atmosphere, for metal processing of materials with high melting points. One of the major sources of metal contamination was thus eliminated. Chromium, titanium, and zirconium have been melted successfully in both small and large static melting units.

A special tensile-testing machine permits the testing of metals at various rates differing by a factor of 100,000 to 1,000,000. A special feature is that the rate of deformation remains constant throughout the test. A determination of the effect of deformation rate at elevated temperature is important to the entire problem of high-temperature metallurgy.

Microscope Stage . . . *and Ferrites*

A new microscope stage permits examination of metal surfaces at temperatures from as low as −190 C to at least as high as 1500 C, at magnifications up to 250×. The stage has been used successfully in studying the supercooling of liquids, decomposition of austenite, grain growth, and other structural changes in metals. It is now possible to detect changes taking place in metals and alloys during heat-treatment or during high-temperature service.

An investigation is in progress in the Research Laboratory to determine the electric and magnetic properties of ferrites, metal oxides with magnetic properties comparable to those of nickel and with such high resistivities that eddy-current losses are negligible at radio frequencies. They have considerably higher permeabilities than metal powders in plastic binders and may replace the latter for many applications. Ferrites are currently being used in television sweep transformers, and they also show promise for concentrating the magnetic flux in induction heating.

CHEMICAL ATTAINMENTS

A NEW primerless, silicone rubber adhesive has been developed in the Research Laboratory. It can be used to form seals and gaskets which are sufficiently leakproof for vacuum systems in laboratories. Oil seals can be made simply. Silicone rubber can also be used advantageously as a laminating adhesive and for joining materials of unlike coefficient of expansion.

WEATHER STUDIES

THERE were numerous interesting developments in Project Cirrus, as weather research sponsored by the Army Signal Corps, Office of Naval Research, and Air Forces is called. Condensation nuclei apparatus was operated in New Mexico, at Schenectady, and from airplanes under varying conditions. Indications were that the instrument may be useful not only in micrometeor studies but also as a monitoring device for certain chemical processes.

Atmospheric observations were continued at Mount Washington Observatory; more than 4500 records were obtained by September 1. Stereoscopic lapse-time motion pictures were obtained of cumulus cloud developments over the sea in flight studies at Puerto Rico. Winter studies included interesting results in seeding stratus clouds with dry ice and silver iodide. Studies of ice crystals in laboratory cold chambers revealed a possible explanation of snow storms which are suddenly developed in clouds not colder than −15 C; ordinarily −39 C is the expected temperature. What happens when a large rain drop freezes? That is under investigation too.

ELECTRONIC ADVANCES

Dyotron . . . *Microwave Generator*

DEVELOPMENTS during the year made possible dyotron oscillators for operation at any frequency between 500 and 3000 megacycles. Originally produced as a microwave oscillator, the dyotron over a wide range of operating conditions can function as a negative resistance. Over certain ranges it behaves like a reactor and can be introduced into a circuit as a tuning aid.

Travelling-wave Tube . . . *Independent of Bandwidth*

The travelling-wave tube is a high-frequency amplifier important not only for its high gain but because it is independent of the bandwidth of the amplified signal. In the tube an electron beam interacts for many wave lengths with an electromagnetic wave which has been slowed down to just a little less than the velocity of the beam.

NUCLEAR AND X-RAY TOOLS

DEVELOPMENT of the multimillion-volt x-ray machines known as betatrons and synchrotrons continued. An improved vacuum tube was produced, permitting operation of an air-cooled 10,000,000-volt betatron at 300 cps, with an x-ray yield of 40 roentgens per minute at 1 meter from the target.

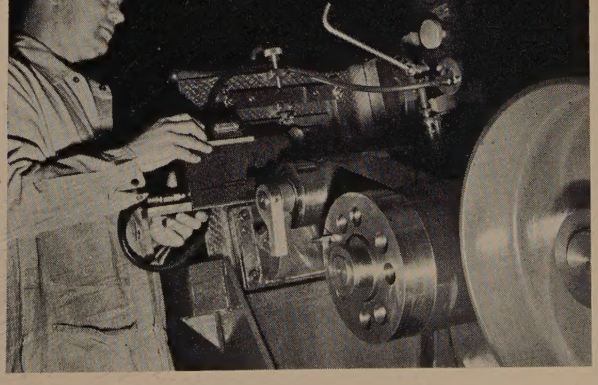
A prototype 70,000,000-volt medical synchrotron was designed, developed, and tested in the Research Laboratory under a contract with the Office of Naval Research. Operating at 60 cps, it produces over 500 roentgens per minute at 1 meter.

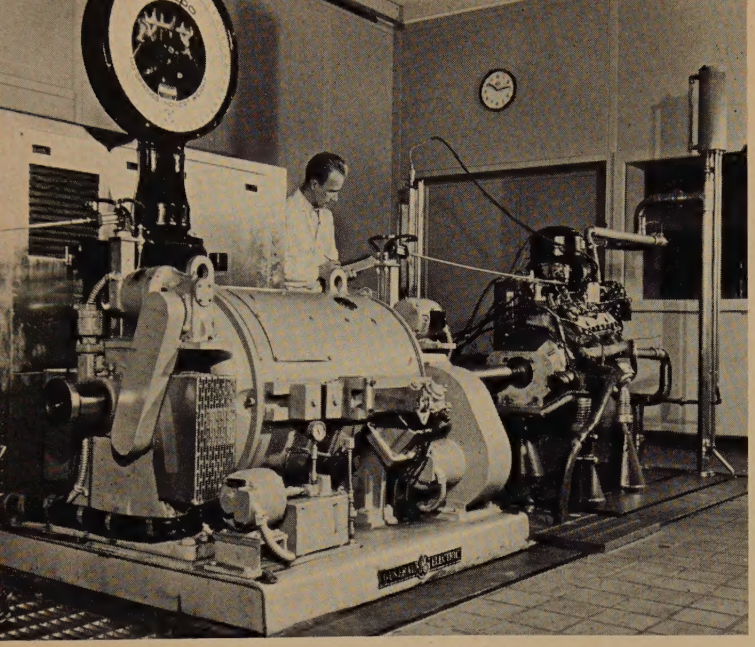
In co-operation with the General Electric porcelain factory, a ceramic tube was developed for use in the medical synchrotron. A low-loss porcelain for high-frequency electric fields will be used for the synchrotron resonator section of the vacuum tube in which the acceleration of the electrons takes place.

Work progressed on The Knolls Atomic Power Laboratory near Schenectady; it will be fully occupied early in 1950. Operated for the Atomic Energy Commission under the supervision of the General Electric Research Laboratory, it will be devoted to the application of nuclear energy to the production of useful power. One activity of this laboratory is the design, construction, and operation of a reactor in a specially built power plant on a 4000-acre tract in Saratoga County, north of Schenectady. The first phase of the building program has started.

The electron diffraction camera, shown here in use, is one of the many special equipments in the Research Laboratory for research on atomic structure, development of new equipment, and crystallographic analyses

Metallurgical studies in the Research Laboratory frequently call for rolling extremely thin sections of metals. The Sendzimir mill seen here will roll specimens to sections as thin as 4 or 5 10,000ths of an inch





One of ten 200-hp dynamometers in the new Ford Laboratory

TESTING AND MEASURING

TESTING EQUIPMENTS

Particle Accelerators . . . *0.1 Percent Velocity Regulation*

AT THE end of the year the Brookhaven National Laboratory at Upton (L. I.) was giving acceptance tests to a 3½-million-volt electrostatic accelerator (FIG. 1) built in the General Engineering and Consulting Laboratory at Schenectady. It is a high-voltage horizontal design of rigid mechanical construction having suitable control auxiliaries for better than 0.1 percent regulation of proton velocities.

A precision laboratory electromagnet was designed and built for Los Alamos Scientific Laboratory, with a field of 10,000 gauss in a 1½-in. gap. The gap distance is adjustable to 0.001 in., and the entire magnet is so mounted on a rotary table that it can be rotated with an accuracy of one sixtieth of a degree. The coils are oil-cooled, and a complete circulating and heat-exchanger system is provided.

A new-type 70,000,000-volt synchrotron for cancer research and treatment was under construction for the University of California Hospital. It will be self-contained and equipped with its own elevating and positioning mechanism so that the x-ray beam can be directed at any point on a patient's body, and from various distances.

Among new equipments for detection and measurement of alpha, beta, or gamma rays or neutrons was a portable instrument with a 4-ft probe to permit examination, from a distance, of an object which might be radioactive.

Network Analyzers . . . *Math Is a Cinch*

Four a-c network analyzers of improved design were built at, and shipped from, Philadelphia. One was installed at Schenectady; another by the Bureau of Reclamation at Denver (FIG. 2); the third by University of California, Los Angeles; and the fourth went to the India Institute of Science at Bangalore. The network analyzer is a computing device upon which miniature replicas of power-system circuits are set up and direct readings taken of the many quantities involved in the complex problems associated with system design and operation. In a few hours it solves problems otherwise requiring weeks of arduous mathematical computation.

Flight Problems . . . *Largest Tunnel*

The largest supersonic tunnel so far built was put into service at the Lewis Memorial Laboratory of the National Advisory Committee for Aeronautics at Cleveland. The tunnel is powered by three 29,000-hp 3-phase 60-cycle slip-ring induction motors operating in tandem.

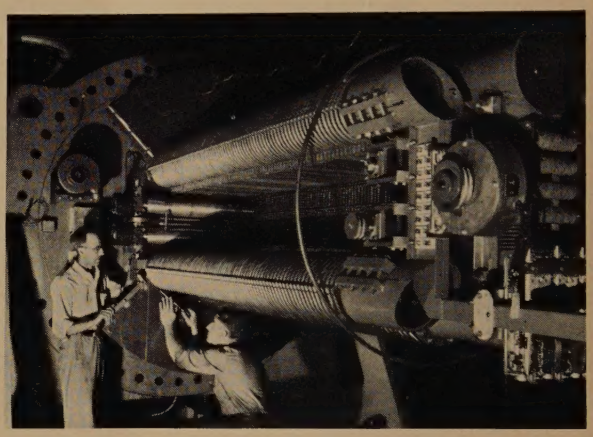


Fig. 1. In this electrostatic accelerator, for Brookhaven National Laboratory, electrostatic charges are carried from one end of the machine to the other by two moving belts

Parachute testing at speeds up to 500 mph will be possible with a new installation at Muroc Air Force Base (Calif.). Parachutes will be whirled about a 120-ft steel tower to test strength, reliability, and design. A 2800-hp adjustable-frequency electric drive will be used.

Automotive . . . *Dynamometers*

The new Ford Laboratory at Dearborn (Mich.), one of the most modern testing laboratories in the world, has been equipped with ten new dynamometers. All are rated at 200-hp absorption, 2500/6000 rpm. They are equipped with motor-rotated trunnion bearings, and remote-operated stator lock.

ELECTRICAL MEASUREMENTS

Meters . . . *True Measure of Kva*

NOVEL application of a direct-heat current-energized thermal element made possible the first watthour thermal kva demand meter for the direct measurement of single-phase kva demand. A resistor,

ontrolled thermally by voltage, has been inserted in eries with the negative-torque spiral of the thermal ement. Operation of the meter is independent of phase elation; thus a true measure of kva is given.

For the magnetic-suspension single-phase watthour eter, previously announced, there was produced a yclometer register. The four numbered aluminum ylinders have vertical shafts, minimizing friction. The eter is easily read, and is practical for self-billing.

A new line of demand registers for electric-utility use industrial plants and commercial establishments aving comparatively small loads was produced in both ndicating and cumulative types. They are of simplified onstruction, with fewer parts, and may be used to onvert most G-E watthour meters into watthour-emand meters.

nstruments . . . *3½-in. Long-scale*

For manufacturers of electronic devices and similar pparatus, as well as for general industrial applications, here is a new line of 3½-inch long-scale panel instru-

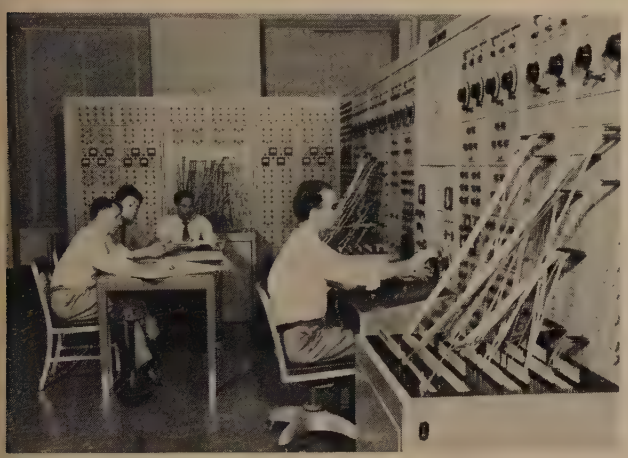


Fig. 2. This improved a-c network analyzer has been made more accurate, with finer adjustment of circuit components

ents of internal-pivot type. The scales are 4.92 in. ong, through 250 deg. They are in the 2 percent-ccuracy class, self-shielding, and in standard round or quare cases.

The scale of switchboard-mounted indicating instruents may be illuminated from any front position ithout objectionable shadows as a result of a circular indow design with a cup-shaped cross-section that xposes the complete scale and permits the scale mechnism to be mounted flush with a narrow bezel.

A new 8¾-in. low-volt-ampere-burden synchroscope as a 360-deg scale with an effective length of 21 in., roviding maximum visibility at long range. When ounted on a hinged panel in combination with a freuency meter and voltmeter, this device supplies the ecessary data for accurate synchronization of two achines.

A lightweight, portable, low-priced oscillograph was esigned for use in schools, colleges, and industrial aboratories for either visual indication or taking oslllograms of current and voltage phenomena. A special film holder using Polaroid Land film is available for producing a finished oscillogram in less than a minute.

With two thermistors in the external circuit, a new portable bridge circuit is so sensitive to a temperature differential that it registers when a hand is brought near one of the thermistors—it is for the accurate measurement of extremely small temperature differentials.

Applying 1000 volts to each of 100 capacitors, a new voltage-multiplier adds them up to produce 100,000 volts. The 100 capacitors are in circular arrangement, permanently connected in series. A rotating arm charges each capacitor separately.

A 200-kv repeating-surge generator was built for university use in testing porcelain insulators. The repeated surges are co-ordinated with the time axis of the cathode-ray oscillograph to provide a standing-wave image of the applied surges on the oscillograph screen.

The capacitance voltage divider was redesigned to provide corona shielding and insure reliable operation under extremely humid conditions.

Current regulators for various magnets were built to hold current constant to ±0.01 percent of any set value within the range of the regulator, and to do it for four hours—a degree of regulation not attainable with previous regulator designs.

An instantaneous electronic line-voltage regulator makes possible a stable source of relatively pure 60-cycle power. It can be used with any type of load up to 200 va and 0.5 pf, and will improve rather than degrade the waveform of the supply voltage.

For the demonstration of wave shapes and properties of electric circuits a new educational device, the harmonic generator (FIG. 3), was introduced. The portable equipment consists of six voltage-generating units mounted on a single shaft and driven by a synchronous motor.

An exceptionally stable wide-range power supply has continuously adjustable voltage output from 500 to 50,000 volts with maximum current of 1 ma. Designed for laboratory applications, it can be used in electron diffraction and mass spectroscopy studies, research on high-intensity screens for cathode-ray studies, electron microscopy, and projection television experiments.

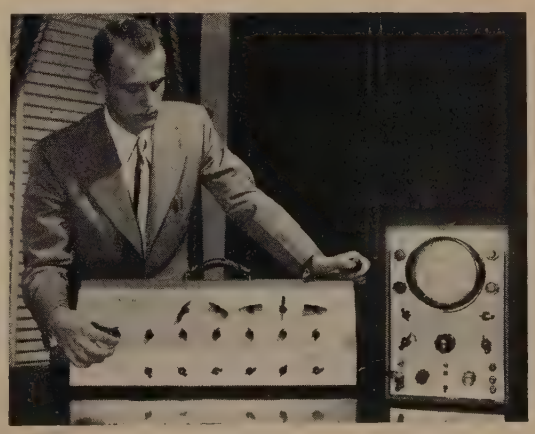


Fig. 3. This harmonic generator instructs science and engineering students in the theories of wave formation. It can produce virtually any wave shape needed in a given engineering problem

Fig. 4. Experiments are easy with this educational amplistat

Fig. 6. Clarity of liquids—water, sewage, or chemicals—is automatically measured and recorded by this turbidimeter

Testing Devices . . . *On the Surface*

A portable contact-resistance indicator was built for measuring resistance below 5000 microhms on contact surfaces. Pressure, applied mechanically, is measured to accuracies within 3 percent of full scale from 0 to 1000 lb. There are three scales: 0 to 50, 0 to 500, and 0 to 5000 microhms.

Measuring the power factor of various insulating materials at various temperatures and voltages is greatly facilitated by a power-factor electrode. The sealed test chamber contains a heater, temperature regulator, circulating fan, and two electrodes. Power factor is measured by means of an a-c bridge.

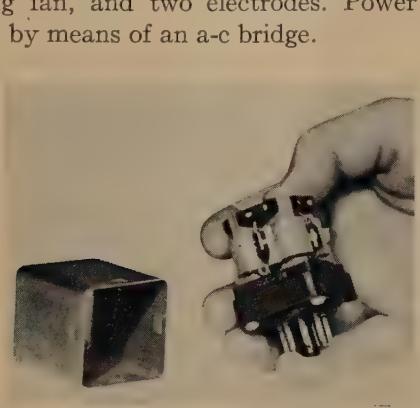


Fig. 5. This plug-in amplistat mounts as do radio tubes

Amplistat . . . *Widely Applied*

To assist engineering students in better understanding of the amplistat, a magnetic amplifier with no moving parts, one (FIG. 4) was built for use in colleges and technical schools. Operating on 110-v 60-cycle supply and rated 100 watts, it is mounted on a special panel with educational-type terminals to simplify its installation in experimental circuits.

A standard line of small high-gain amplistats, operating on the saturation effect in iron, was produced for 400- or 60-cycle power. They mount as do radio tubes (FIG. 5). Rated up to 2 watts and providing power gains up to 4000, they supply either unidirectional output current or reversing output whose direction corresponds to the input.

MECHANICAL TESTS

REPLACING quartz, rochelle salt, ammonium dihydrogen phosphate, and numerous other magnetostrictive materials, barium titanate was found to offer many advantages when used in transducers, which convert electrical into mechanical vibrations. Transducers may be molded into any desired shape when this newly developed compound is used.

Assistance to chemical reactions, bacteria control, and the mixing of immiscible liquids such as oil into water are among the applications of the ultrasonic generator having its transducer on top of the power supply and operating in an oil-filled well. Power at 300, 500, 750, or 1000 kc is supplied by the equipment.

The beta-ray gage, a noncontacting thickness gage, makes use of radioactive materials produced at Oak Ridge. Operating on the principle of determining weight per unit area, the gage can be used to measure continuously the thickness of such materials as paper, rubber, plastics, textiles, and steel up to 0.050 in. thick.

Several magnetic couplings and clutches for special applications were built in the General Engineering and Consulting Laboratory. Included were magnetic-fluid, eddy-current, and salient-pole synchronous types.

Motor-brush wear has been studied by employing brushes containing radioactive silver. The motor is operated, and a photographic film then wrapped around the commutator. The developed film shows the distribution of the radioactive particles worn from the brushes and deposited on the commutator.

Wider usefulness has been given the metals comparator by the development of a new test head, so designed that the part to be tested is simply placed across the end of the solenoid.

CHEMICAL TESTS

FIRST units of an improved analytical mass spectrometer, providing automatic recording and ratio-changing, were shipped during the year. The instruments embody such features as spectrometer-tube and

ontrol-unit accessibility, fine regulation of ionizing nd accelerating voltages, and magnetic-field currents or beam separation.

Automatic measurement and recording of the mount of suspended particles in a liquid is the function f a recording turbidimeter (FIG. 6) for water and ewage treatment and chemical plants. It measures the atio of scattered light to transmitted light.

An improved chemical-type detector for boiler-tube eaks in mercury-vapor power-generating stations perates on the principle that selenium sulphide will urn from yellow to gray or black in the presence of ercury vapor.

TIMING DEVICES

Speeds of rotation up to 15,000 rpm can be measured o within 1 rpm by a new electronic pulse counter. The igh-precision tachometer (FIG. 7) consists of a photo-lectric or magnetic-pulse tachometer, an electronic ounter which counts up to 50,000 pulses per second, nd an indicator which converts the pulses to rpm and ashes the rpm on an opal-glass screen.

OPTICAL EQUIPMENTS

TO AID in the study of fluorescent materials, the search for new phosphors, and the design and anufacture of light sources, a new color-sensitive in-rument called a recording spectroradiometer has been eveloped.

The new device breaks up a light beam from any ource into its spectrum, measures the relative spectral nergy at each wave length, and makes a permanent cord of the measurements in the form of a graph.

An exposure meter about half the size of a standard garette package, and weighing only 2 oz, was devel-oed for use with the Polaroid Land camera. The scale calibrated in numbers that correspond to markings on at camera.

A sensitive lightmeter, designed specifically for reet-lighting surveys, has 0 to 1 and 0 to 5 footcandle ales, with a range of sensitivity and accuracy not reviously available.

A low-cost photoflash tube was a co-operative evelopment of lamp, transformer, and research labora-ry workers. The tube, with a newly designed power ack, offers a light source of greatly increased efficiency.

TEMPERATURE

A TEMPERATURE recorder was developed to test performance of refrigeration controls. Forty controls are tested simultaneously, and the temperatures at which they open are automatically marked on a strip-chart recorder. The instrument covers temperatures of −20 to 70 F in 9 ranges of 10 F each.

INDUSTRIAL X-RAYS

TWO more 2,000,000-volt industrial x-ray machines were installed during the year by the General Electric X-Ray Corporation, Milwaukee. One went into the Renfrew (Scotland) plant of Babcock & Wilcox for examining heavy pressure vessels (FIG. 8); the other into the Atomic Energy Commission plant operated by General Electric at Hanford (Wash.).

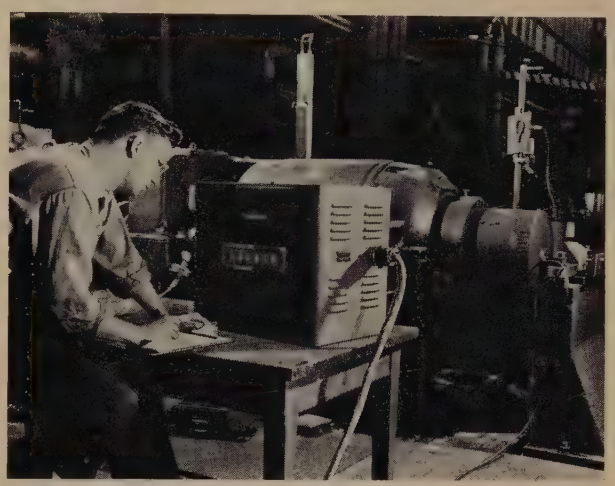
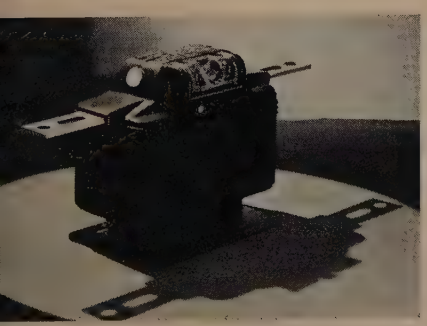


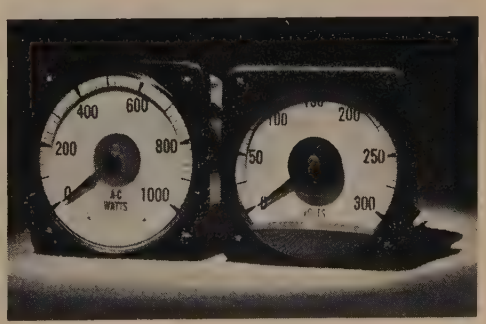
Fig. 7. Measuring the rpm of a steam turbine-generator with an electronic pulse counter which is accurate to 1 rpm at 15,000 rpm. At the far right, the electromagnetic tachometer generator can be seen installed on the shaft of the machine under test

Working on the Railroad . . . *P. R. R. the First*

First results from the application of x-rays by the railroad industry were made public during the year by Pennsylvania Railroad officials. A truck-mounted 250,-000-volt machine is being used in its Altoona (Pa.) Test Department, adjacent to its large manufacturing and maintenance shops, to guide the manufacture of new and replacement parts of railroad equipment; for occasional inspection of used parts whose condition is questioned; and as an aid to the Purchasing Depart-



The first of the butyl-molded line of instrument transformers. The butyl compound, injected under high pressure into the area around the core, coils, and terminals, provides a homogeneous insulation that is resilient, oxidation-resistant, arc-resisting, and highly resistant to moisture



External illumination from any front position provides even lighting distribution on the scale of this improved switchboard instrument (left)

ment in determining the quality of products it proposes to buy.

For Golfers . . . *Concentricity Shown*

In co-operation with the Wilson Sporting Goods Co. of Chicago there was developed at Milwaukee a sales-promotional x-ray fluoroscope. Wilson takes the unit (FIG. 9) by station wagon to major golf-course clubhouses throughout the country, to demonstrate the concentricity, shape, and location of core of its new Isotropic ball—properties which only x-ray fluoroscopy can demonstrate nondestructively.

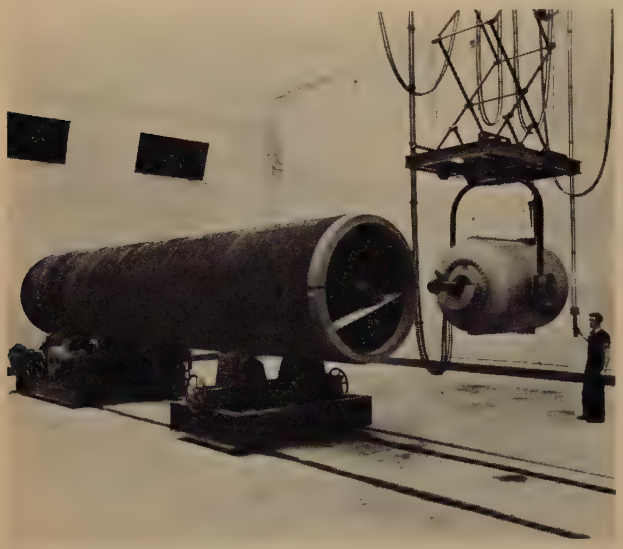
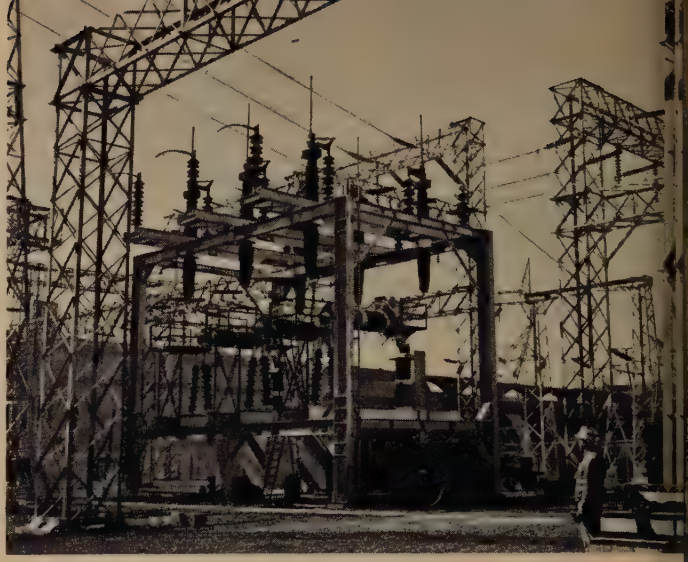


Fig. 8. The 2,000,000-volt x-ray machine is dwarfed by the huge forging, welds of which are being inspected at the Renfrew, Scotland, plant of Babcock & Wilcox, makers of pressure vessels, with headquarters at Barberton (Ohio)

Fig. 9. Ellsworth Vines (*left*) shows his brother Ed, pro at Northmoor Country Club, Highland Park (Ill.), how to test golf balls with an x-ray fluoroscope for uniformity of construction, and for shape and location of the center core



A 10,000,000-kva 230,000-volt impulse-breaker switching unit being erected in the switch yard of the Grand Coulee Dam power plant *Courtesy Bureau of Reclamation*

POWER

POWER GENERATION

Gas Turbines . . . *In Operation*

THE first 3500-kw simple-cycle-combustion gas-turbine power plant (FIG. 10), essentially a duplicate of the locomotive design (page 38), was placed in successful operation in July at the Arthur S. Huey Station of Oklahoma Gas & Electric Co., using natural gas for fuel. In addition to the kw-hr generated, the recovery of waste heat from the gas-turbine exhaust permits the heating of boiler feed-water for the 50,000-kw steam power plant, with an additional pickup of 2500 to 3000 kw by the existing steam turbines.

Another gas turbine duplicating the locomotive design was installed in the Schenectady Works as a compressor drive, to supply air for various factory and test uses.

For a 3500-kw gas turbine, which will be installed in the Farmingdale Station of the Central Maine Power Company, switchgear engineers at Philadelphia designed a fully automatic equipment for starting and stopping the turbine. In properly timed sequence, the equipment for starting will: energize the turning gear to "break away" the unit; start the cranking motor to bring the unit up to partial speed; open the fuel valve; ignite the fuel; allow the unit to accelerate under its own power; and transfer the fuel supply from starting diesel fuel to Bunker C for running.

Steam Turbines . . . *Large, Efficient*

Among noteworthy turbine-generator units shipped or installed in 1949 was a 150,000-kw tandem-compound double-flow 1800-rpm unit put in operation in the Fisk Station of Commonwealth Edison Company. It was built for maximum capacity of 165,000 kw, with

team conditions of 1250 psig and 925 F, and is the rgest unit so far put into service at 1250-lb steam ressure. The 1800-rpm 176,470-kva generator is ydrogen-cooled by eight vertical coolers, four along each de of the generator. The one-piece stator (FIG. 11), hysically the largest so far constructed and shipped or hydrogen-cooling, weighs 398,000 lb.

The first of two 100,000-kw 1800-rpm turbine-enerator units went into service at the Trenton Chan-el Plant of Detroit Edison Company. They are andem-compound, double-flow, condensing-type, with team conditions of 1300 psig and 950 F. The 125,000-va generators are also hydrogen-cooled.

The first two of six identical 125,000-kw cross-com-ound units for a utility system were installed this ear. These units are expected to be the most efficient f central-station steam installations in the world.

TRANSFORMERS

igh-voltage Engineering . . . *15,000,000-volt Laboratory*

A SPECTACULAR new High Voltage Engineering Laboratory (FIG. 12) was completed at Pittsfield Mass.), providing wider horizons for research and evelopment work in studying lightning and lightning rotection, and in the design of electric equipment etter able to withstand damage from lightning. In he laboratory are 11 high-voltage testing transformers, n sizes from 100 to 350 kv rms; three of the 350-kv ransformers are connected in cascade to produce 1050 v, and there are provisions for later obtaining 1750 v from the available transformers.

ower Transformers . . . *110,000 Kva*

Production of power transformers at Pittsfield was he largest in its history. One, a 110,000-kva unit elivered to the Oswego Steam Station of Central lew York Power Company, was the largest-capacity ransformer yet delivered by the Company. The three-hase transformer is rated 115,000 to 13,200 volts, and as forced-oil-air cooling.

The largest self-cooled transformer ever built at ittsfield, rated 75,000 kva, was installed by the louston Lighting and Power Co. It has provisions for ncreasing the rating to 93,750 kva by addition of fans.

Seven transformer disconnecting switches built for the epartment of Water and Power, City of Los Angeles, lso set a size record. The transformers are rated 3,333 kva, single phase; and the switches (FIG. 13) re installed on the 132,000-volt side.

igh-voltage Specialties . . . *Multiplying Voltage*

Cascade connections of from one to four 35-kv 32-ma ectifiers of new design provide an efficient and eco-omical means of multiplying voltage ratings in labora-ory or factory testing and power-supply applications here smooth d-c voltages are required.

Specialty Transformers . . . *25 Decibels Fewer*

A new device known as a permanent-magnet current reference converts a-c power into direct current which is constant to a high degree of accuracy despite rela-tively large variations in source voltage and frequency.

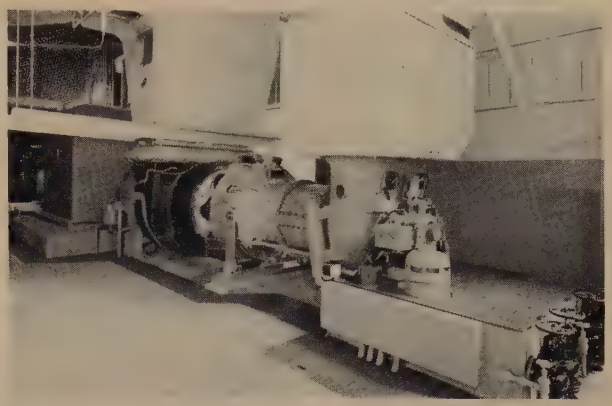


Fig. 10. This country's first combustion gas-turbine power plant for land installation. It is in service in Oklahoma, using natural gas as its fuel

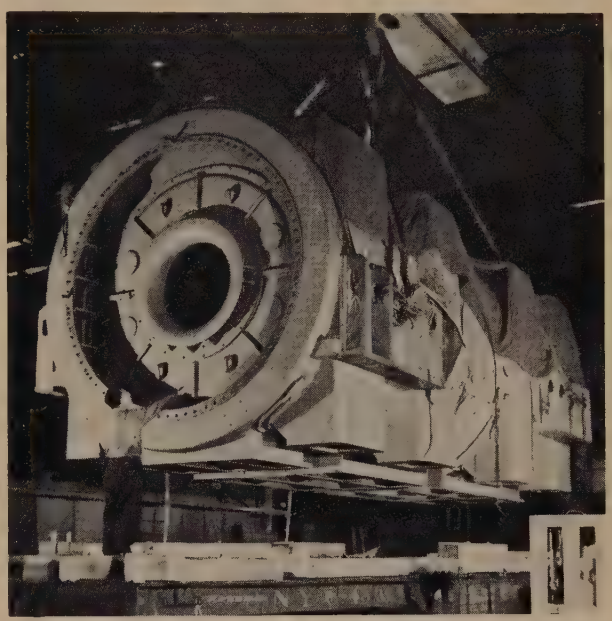


Fig. 11. This 199-ton stator is for a 150,000-kw turbine now in the Fisk Station of Commonwealth Edison Company

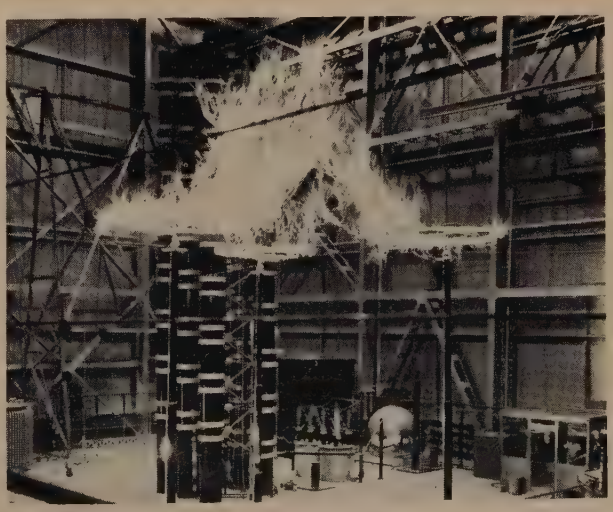


Fig. 12. Noise similar to that of Fourth of July fireworks resounds through the High Voltage Laboratory as streamers rise 20 ft into the air from three revolving electrodes when a 60-cycle 3-phase arc is created

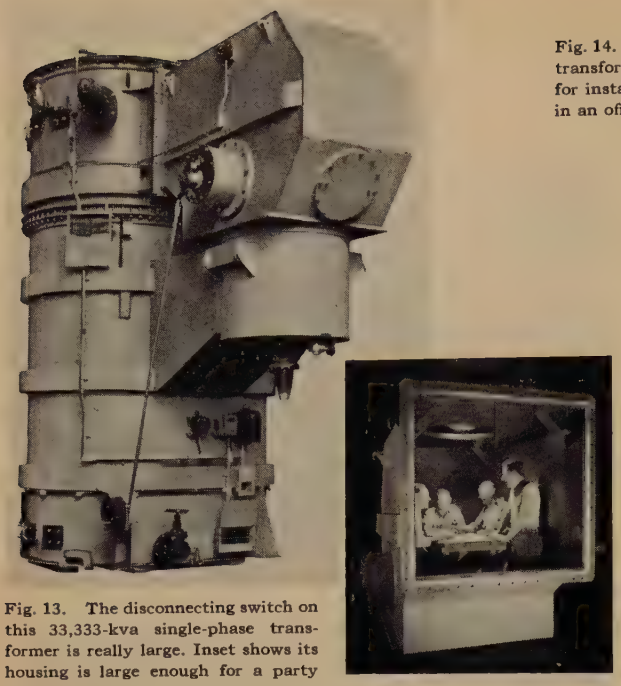


Fig. 13. The disconnecting switch on this 33,333-kva single-phase transformer is really large. Inset shows its housing is large enough for a party

Fig. 14. Operating noise of Type D transformers was greatly reduced for installation in unusual locations in an office building

A high-quality, low-cost, horizontal-sweep transformer for television receivers has a laminated iron core, paper-layer insulated coils, and standard specialty-transformer construction throughout.

Several Cleveland office buildings changed over from direct to alternating current during the year. In the Union Commerce Building it was necessary to install Type D transformers in stair wells and electrical cut-out closets, among other places (FIG. 14). Quiet transformers were needed, and obtained. By use of special sound-insulating barriers both within the core-and-coil and on the surrounding case, and by careful choice of core materials along with special design of core and coil, the challenge was met.

TRANSMISSION

REDUCED electric losses keynoted the development of a new line of strain and suspension clamps produced by Locke Incorporated, of Baltimore (Md.). The line includes 9 suspension clamps and 3 strain clamps to accommodate all popular sizes of ACSR and all aluminum conductors used for high-voltage transmission.

Several suitable glazes were devised for application on high-strength low-thermal-expansion porcelain bodies produced by Locke. White, aquamarine, and olive-drab glazes were produced, all with excellent gloss, smoothness, and coverage.

SWITCHGEAR

10,000,000-kva Package . . . *Simple, Compact*

1949 saw completion and delivery to the U. S. Bureau of Reclamation for the Grand Coulee Dam switchyard of the first 10,000,000-kva 230,000-volt completely co-ordinated package switching units ever built (p. 18), combining: the highest-rated commercial power circuit breakers ever built; disconnecting switches having entrance bushings for the accommodation of bushing current transformers; and a factory-built self-supporting structure of simple, compact design. Work was also begun on an order for 16 similar units to be delivered in 1950.

Metal-clad Switchgear . . . *Tested Conveniently*

Safe and convenient means for grounding and testing the primary circuits of metal-clad switchgear are provided by a new device (FIG. 15) which is inserted in place of the vertical-lift magne-blast breaker when it is desired to ground either the bus or line for maintenance work or to apply high potential in fault-location tests.

Fig. 15. A voltage check being made with a grounding and testing device inserted in a metal-clad switchgear unit. Test receptacles provide for the application of hot stick or test plugs to all six breaker terminals

Low-voltage Drawout . . . *40 Percent Space Saving*

Integral rackout mechanisms, standardized unit construction, and compact, co-ordinated bus structures —as well as a saving of approximately 40 percent in floor space—are among the features of new low-voltage drawout air-circuit-breaker equipments. The design is co-ordinated with those of standard transformers and industrial-control equipments to permit use of standard equipments in load-center unit-substation assemblies for both indoor and outdoor service.

Outdoor Switches . . . *4000 in.-lb Torque*

Many of the larger high-voltage outdoor switches required separate reduction gears because of torque limitations of previous designs of motor-driven operating mechanisms. A new mechanism, with 4000 instead of the previous 1500 in.-lb torque, makes such gears

innecessary. Auxiliary switches indicate switch position regardless of whether the mechanism is connected to the switch shaft.

Supervisory Control . . . *Factory-assembled Unit*

A new standardized unit-construction supervisory control system, which can be used with any type of communication channel, is adaptable to any type of switchboard construction by reason of its standardized assembly in small unit cases, and can be easily expanded or changed over for use with a different type of communication channel.

Protective Relays . . . *After Extended Outage*

Utility companies for many years have had the problem of providing fault protection for distribution systems and at the same time being able to pick up load on feeders after outages of sufficient duration to bring onto the lines the loads of practically all automatic devices such as oil burners, refrigerators, water pumps, etc. A new overcurrent relay to handle such situations makes use of a wattmetric-type operating magnet with the coils connected in series but otherwise similar to standard Type IAC relays to produce the extremely inverse characteristics necessary.

UNIT EQUIPMENTS

A NEW package substation for rural applications (FIG. 16) consists of an incoming-line section suitable for terminating one or two 22,000- to 69,000-volt lines and mounting disconnecting switches, fuses, and lightning arresters, together with provision for high-voltage metering equipment. A transformation section contains four single-phase transformers (one spare) in bank sizes up to and including 1500 kva. There is an outgoing feeder section with provisions for up to four 12,470Y/7200- or 13,200Y/7620-volt feeders protected by oil circuit reclosers.

Unit Power Plant . . . *Topping Plant*

An industrial application of mercury-unit power-plant equipment went into service at the Pittsfield plant of the General Electric Co. This is a topping plant producing 7500 kw from the mercury turbine-generator and in addition providing some 115,000 lb of steam per hour at 650 lb. 825 F to drive existing steam turbines. All equipment was co-ordinated as a unit including the mercury boiler and auxiliaries, mercury turbine-generator, condenser boiler, piping, and control equipment.

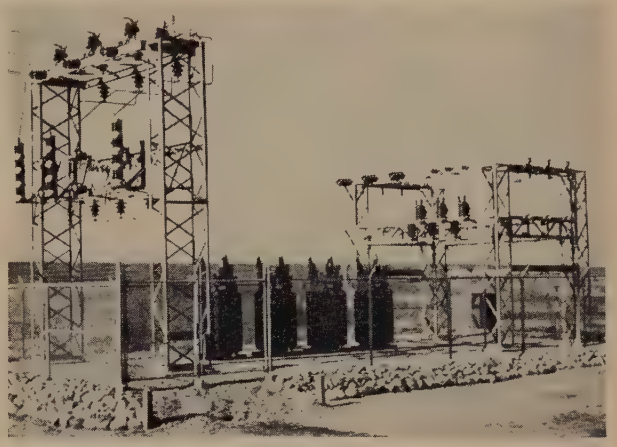


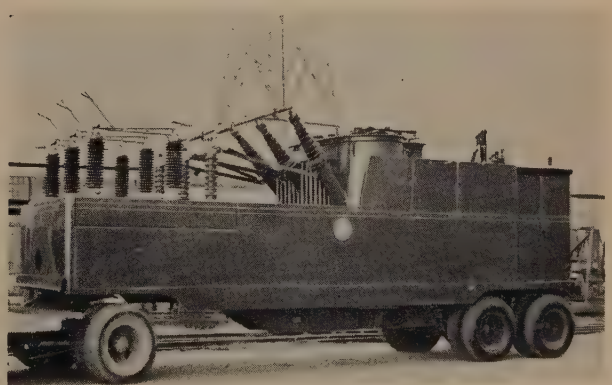
Fig. 16. The 750-kva rural package substation of the James Valley Electric Co-operative, Millarton (N. Dak.)

CAPACITORS

THE possibility of working on live equipment has been eliminated by use of an ingenious system of improved interlocking doors in combination with line breakers and circuit switches in a new line of power-capacitor equipments made up of 25-kvar capacitors. Covered ventilating screens in top and bottom of capacitor housings provide improved natural ventilation; thermostatically controlled fans give forced ventilation when required.

The largest cylindrical, petticoated porcelains ever made—76 in. long, 23 in. outside diameter, 16 in. inside diameter—are being produced at Baltimore. A total of 192 of them will be used as top and bottom porcelains in 96 outdoor, back-connected, disconnecting-switch bushings, with self-contained bushing-type current transformers. They are part of 10,000,000-kva, 16/230-kv switchgear units being built at Philadelphia for the Pacific Gas and Electric Company

One of the largest 3-phase mobile unit substations to be completely assembled and shipped in one package has a rating of 4500 kva, 69,000 to 2400/4160 Y, 7200/12470 Y volts, 60 cycles. This was furnished the Central Power & Light Company of Corpus Christi (Texas)



A new line of capacitors was specially adapted for oil-field service but is equally usable in industrial plants. They can be mounted easily in any position, for direct connection to the motor starter, and automatically provide power-factor improvement when needed.

Continuous operation above 85 C is a feature of new small d-c paper-dielectric capacitors (FIG. 17) in which the impregnant is Permafil. Able to operate at 100 C without derating, these capacitors actually can be used in ambient temperatures up to 125 C.

A sealed-for-life capacitor has been achieved by using a permanently elastic silicone bushing to compression-seal the neck of the deep-drawn aluminum case.

Fig. 17. The temperature of boiling water means little to these capacitors—they're designed for continuous high temperatures

A new capacitor switch, low in price, will encourage capacitor installations on high-voltage distribution circuits. Rated 15,000 volts, 100 amp continuous, 3-phase, it is oil-immersed, electrically operated, and designed for outdoor use.

ARRESTERS, CUTOUTS, AND FUSES

Arrester Cutout . . . *Unit-combination*

LOW-COST protection of conventional distribution transformers on rural lines is given by a new unit-combination arrester and cutout (FIG. 18) which combines the basic design features of the 9-kv hi-stroke arrester and the 7.8-kv 50-amp flip-open cutout. For lines rated 7200/12470 and 7620/13200 volts grounded Y, the unit combination costs 20 percent less than the items separately.

Pellet Protectors . . . *On Secondaries*

Service experience, field investigations, and laboratory work have shown that some primary and secondary insulation failures have resulted from lightning currents entering distribution transformers through low-voltage secondary leads. The rate of such failures can be reduced more than 75 percent when lightning arresters are applied to secondaries as well as primaries—and this application is economically justified where bad exposure of secondary circuits exists.

Tests proved that, on rural circuits, lightning surge currents arriving over secondary leads were of nearly the same frequency and severity as those arriving over primary leads. Pellet protectors were successfully applied to the secondary terminals, not only reducing the impulse voltage across secondary terminals but also shunting the peak currents to ground and thus by-passing the secondary winding. The pellet protector, in an aluminum container 2⅜ in. diam and 2¼ in. long, is capable of discharging 65,000 amp of lightning currents.

Service Protector . . . *Thyrite*

A new Thyrite lightning protector was developed for meters, industrial power-service entrances, and consumer apparatus. Rated 0 to 650 volts, it is available for indoor or outdoor installation, on single-phase or polyphase circuits.

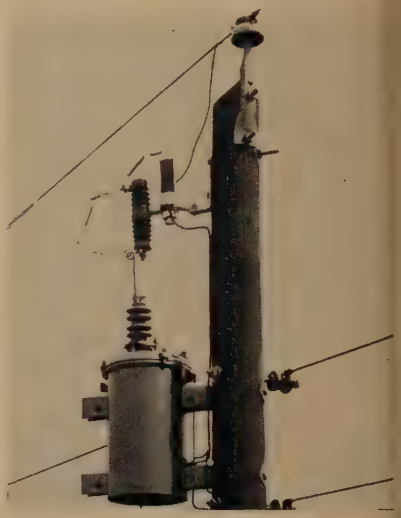


Fig. 18. A money-saving unit-combination arrester and cutout mounted above the transformer on a rural distribution line

Oil Fuse Cutouts . . . *Switching Mechanism*

A pole-base switching mechanism was designed for ground control of pole-mounted, gang-operated, oil-fuse cutouts of any rating, in either two- or three-phase installations. The mechanism permits easy switching for primary control of sportslighting circuits, or for fused sectionalizing of lines.

Fuse Links . . . *Dual Characteristics*

Hi-surge fuse links were made available in ratings of 2, 3, 5, and 8 amp for overcurrent protection. These links also provide protection against surges equivalent to that of a conventional 10-amp universal cable-type fuse. The links provide improved overcurrent protection where 10-amp minimum fusing was previously used.

VOLTAGE REGULATORS

AN EIGHT-STEP rural-line voltage regulator was developed, superseding the 4-step equipment which previously was standard. The new equipment (FIG. 19) has a 10 percent range, covered in eight 1.25 percent steps—changes in voltage which are imperceptible as light flicker. Having control accuracy comparable to that of station-type regulators and a regulation bandwidth narrow enough to take advantage of this accuracy, the equipment is expected to be the inexpensive answer to urban-fringe regulation problems.

An induction-voltage regulator, together with a cir-
it breaker and transformer, was supplied for the
wer-conversion system to supply a 3-phase full-wave
idge rectifier for a 60-in. cyclotron. The equipment
for nuclear-research use at the University of Wash-
gton. The oil-filled regulator is manually controlled
d motor-operated, with a rating of 133 kva, 42.5 amp.
put voltage is 2300 volts and output 4100 volts to 512
lts. The output is the supply for the 3-phase, 60-
cle, 300-kva, 4100-delta/14000-Y-volt, oil-filled trans-
rmer, which in turn feeds the full-wave bridge recti-
r.

CABLE

eoprene Jacket . . . *Glass-reinforced*

ONE of the outstanding cable developments during the year was glass-reinforced Neoprene hose cket. The greater fiber strength of the glass makes it ssible to reduce considerably the jacket thickness and erefore the over-all diameter of the cable, without ss of mechanical strength. Moreover, because of the wer absorptive power of glass as compared to cotton, ss moisture will be present in the jacket, resulting in gher insulation resistance and a superior durability in rvice.

wer Cables . . . *Longest Under Water*

The high-resistance, low-loss, skid-wire shield sembly, which materially reduces the loss in pipe bles, has been established as a standard in the dustry.

The first self-contained high-pressure gas-filled cable r 110,000-volt ungrounded-neutral service was in-alled at Langley Field (Virginia) and it is understood have met all expectations in regard to simplicity d reduction in installation time and costs.

The laying of power cables across Galveston Bay, e longest high-voltage submarine power cable cross-g in this country, was made possible by the develop-ent of satisfactory submarine joints for 3-conductor -kv oil-filled cable.

Large 3-conductor 69-kv medium-pressure gas-filled ble was developed and directly buried or installed in ducts in Washington (D.C.). Previous high voltage was 45 kv, at the Panama Canal.

A new power cable has been developed for use in infrared ovens and similar high-temperature applications where temperatures are far too high for ordinary asbestos-type power cables. This type of cable, designated as Teflon, is rated 600 volts and can be operated at 250 C with nickel, nickel-clad copper, or monel metal conductors, or 150 C with copper conductors.

Cable Accessories . . . *Simple Press*

In the field of cable accessories, single-ram and four-ram connector presses were developed for pressure-attaching connector sleeves for jointing and terminating power cables. The designs utilize round punches for indenting the sleeves into the cable, giving a connection whose resistance is equal to, or better than, the equivalent cable and whose compacting is complete.

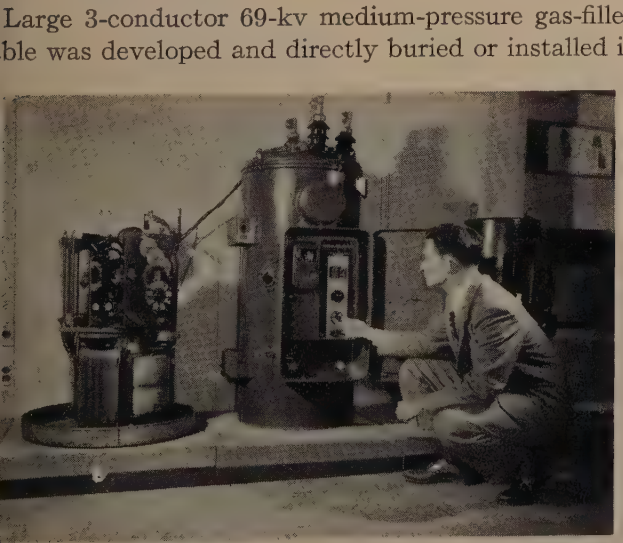


Fig. 19. This voltage regulator for rural service gives eight voltage boosts in 1¼ percent steps, so small as to cause no perceptible light flicker

CARRIER CURRENT

FREQUENCY-MODULATION carrier-current communication equipment was redesigned for better modulation limiting and frequency stability, and to reduce harmonic output.

A new frequency meter and signal generator for use in installing and maintaining carrier-current equipment delivers several volts of carrier at 30 to 200 kc. As a frequency meter it permits accurate measurement by the heterodyne method, and includes a 100-kc crystal for calibration. Easily portable, it operates from 117-volt a-c supply.

Microwave equipment, for operation on 960 mc, was supplied for three stations of the Southern California Edison Company, for telephony as well as supervisory control and telemetering.

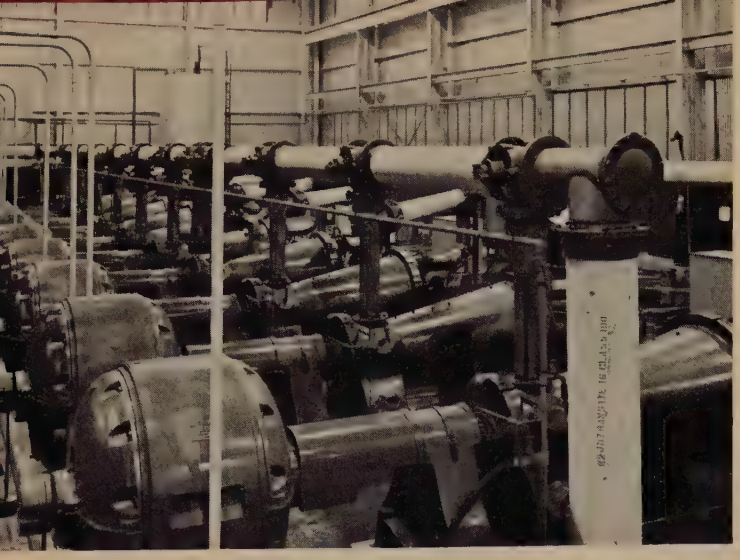
The four movable loading towers and three remote stations of the new coal-loading pier of the Chesapeake and Ohio Railroad at Roanoke (Va.) (page 29), were supplied with two-way frequency-modulation communication equipment.

RECTIFIERS AND CHARGERS

THE oil industry was particularly in mind in the development of an oil-immersed selenium rectifier for cathodic protection. Overcoming the difficulties previously encountered with rectifiers in this application, it has corrosion-resistant oil-immersed selenium stacks, double casing for protection from the elements, and panel construction for easy servicing.

As components in industrial products where continuous service 24 hr a day over a period of many years is not demanded, high-voltage selenium rectifier stacks were produced, offering both space and money savings.

Users of materials-handling equipment can reduce costs with a sequence charge control which, when attached to a lead-acid battery charger, permits the charging of two batteries from one charger.



These ten Jordan drives in a paper mill are each driven by its own 400-hp Tri-Clad synchronous motor

INDUSTRY

MOTORS

Large Motors and Generators . . . *Impressive Applications*

THERE were numerous noteworthy applications of large motors and generators during the year in a wide variety of industries. In a paper mill, for instance, there were installed approximately 85 motors of various types and sizes, as well as motor-generator sets, exciter sets, control, and switchgear.

Among numerous steel-mill installations was one having 13 main-drive motors in two groups to drive its 15 stands. Special characteristics built into these motors maintain a close steady-state speed regulation, and minimize speed changes in each stand under sudden load changes.

Tri-Clad high-speed synchronous generators helped solve the problem facing the City of Beaumont (Texas) in its installation of a standby power plant for water-pumping stations. Two 400-kw 2400-volt 1200-rpm 3-phase 60-cycle generators were directly connected to diesel engines. The two units have a combined capacity of 800 kw at 0.6 power factor, and operate continuously under full-load capacities throughout 24-hr periods without attention except for lubrication.

The Granby pumping plant, operating heart of the Big Thompson Project of the Bureau of Reclamation (Colorado), has called for a wide variety of electrically powered construction tools. The pumping plant (FIG. 20) will include three 200-cfs vertical-shaft single-suction centrifugal pumps operating under a variable head from 95 to 186 ft, each powered by a 6000-hp motor.

A special vertical hollow-shaft synchronous motor of 450 hp, 1200 rpm was installed to irrigate a Hawaiian pineapple plantation. Water is pumped from 615 ft below ground to a reservoir 300 ft above the pumping station, at a rate of 1100 gal per min. The total running thrust on the 17-in. diam, 1200-rpm plate-bearing is 50,000 lb. A high-pressure pump and hydraulic jacks slightly raise the motor rotor, pumpshaft, and impellers before each start, introducing an oil film between the thrust-bearing surfaces and thus practically eliminating breakaway torque.

Ball-bearing motor-generator sets for shovel service had single-bearing generators coupled to a two-bearing motor through solid couplings—couplings that had a tapered bore to form a rigid assembly—were relatively expensive, and critical in assembling. A new keyless coupling, with a straight bore, is assembled on the shaft with sufficient interference fit to transmit all the torque required, with a liberal factor of safety. A circumferential groove permits high-pressure oil to be pumped in with a hand pump, to expand the bore sufficiently for easy removal of the coupling with an ordinary hand-type bearing puller.

Fig. 20. In the foreground is the partially completed Granby Pumping Station (Colorado). The Colby electric crane on the steel tower is 150 ft above the ground

Small and Medium Motors . . . *Package Equipments*

Rising production costs emphasized the importance of adjustable-speed drives to make machines more productive, more versatile, and more accurate, together with improved quality, increased output, and lower production costs. This trend emphasized the advantages of package equipment, with the integrated factory-assembled generator, motor, and control in one case, ready for connection.

The ACA adjustable-speed induction motor was extended up to 20:1 speed range, with speed adjustable either remotely or by a dial on top of the motor. The

CA gear-motor for low adjustable speeds, 602/201 35/12, was developed in 3- to 15-hp ratings; it cludes a standard AGMA Class II, open, horizontal ar unit and standard Tri-Clad ACA motor in one mpact unit.

The speed variator, for d-c adjustable-speed per-rmance from a-c power, was extended to a 60-hp ckage unit. Self-supporting bases eliminate the need r special concrete or steel foundations in the 30- to -hp sizes. High-pressure ventilation keeps out dirt d foreign matter, thus reducing the maintenance pense.

A newly developed electronic speed variator (FIG. 21), mbines the relatively inexpensive power rectification the speed variator with the accuracy and versatility a regulated all-electronic drive. Since it converts ost of its power in the rotating rectifier, it needs only nall easily replaceable low-cost power tubes.

In the paper industry a package speed variator with mplidyne control was advantageously applied for justable-speed drive of a wet-end helper drive. Still other package unit was the Tri-Clad a-c generator. his synchronous generator with static magnetic gulator uses a block-compensated amplidyne exciter.

A line of package 400-cycle motor-alternator sets as developed for application as a ground power pply, mainly for testing aircraft which have their wer system converted to 120/208 volts, 3-phase, 400 cles. The unit includes a 60-cycle motor and 400-cle alternator.

A new group of motors for hand-operated battery ucks has compound windings. About 20 of the former ame sizes are eliminated, reducing motor costs.

Tri-Clad high-frequency induction generators were ade available in ratings of 250 kw and lower for duction-heating applications requiring single-phase gh-frequency current from 960 to 10,000 cycles. he two-unit four-bearing set has a standard Tri-Clad ipproof squirrel-cage induction motor connected by xible coupling to a newly designed generator.

A new Tri-Clad single-phase capacitor motor IG. 22) was developed in ratings from ½ to 5 hp. he new motor is streamlined, compact, and light-

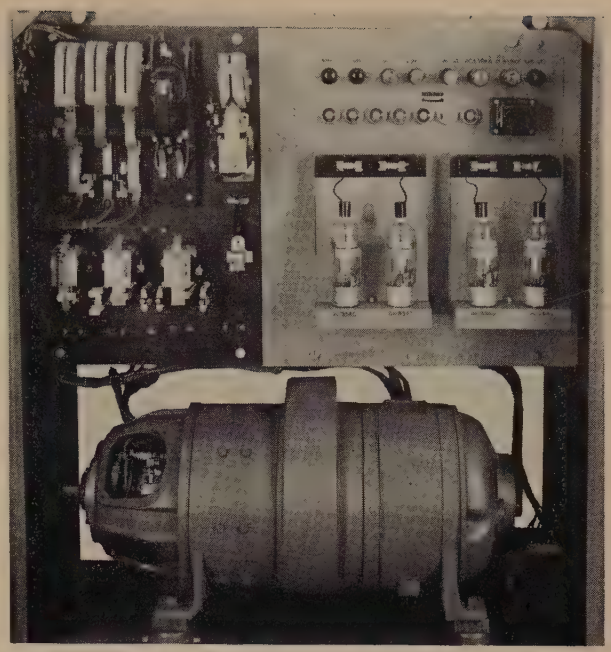


Fig. 21. The electronic speed variator, among other uses, provides stepless adjustable speed and maintains speeds on overhauling loads

weight. It has a totally enclosed transfer mechanism, long-life ball bearings, and a built-in terminal board in the end shield to replace the conduit box. To further minimize over-all dimensions, the capacitor units are now mounted in the base of the motor rather than on top.

Also developed were a new Tri-Clad brake motor, and a high-torque, high-slip NEMA Design D induction motor, in 50- to 150-hp ratings (FIG. 23).

Fractional-horsepower Motors . . . *Smaller*

Now there is a synchronous motor which is as small as the corresponding induction motor. An alnico permanent magnet is used for rotor excitation.

A new line of unit-bearing shaded-pole motors was developed for higher efficiency, quieter operation, and increased output, in ratings from 1/40 to 1/12 hp at 2-, 4-, and 6-pole speeds.

For a special aircraft application there was produced a miniature d-c servo-motor rated at 2/1000 hp at speeds in excess of 6500 rpm, sufficiently sensitive to be

Fig. 22. New integral horsepower Tri-Clad single-phase capacitor motor, smaller and lighter than previous motors

Fig. 23. The totally enclosed fan-cooled extended-bar motor; heat dissipation outside the motor allows it to handle more severe duty cycles

Fig. 24. A more compact gasoline-pump motor; its trunnion-mounted base, securely fastened to the motor by extensions of the motor overbolts, is removed readily

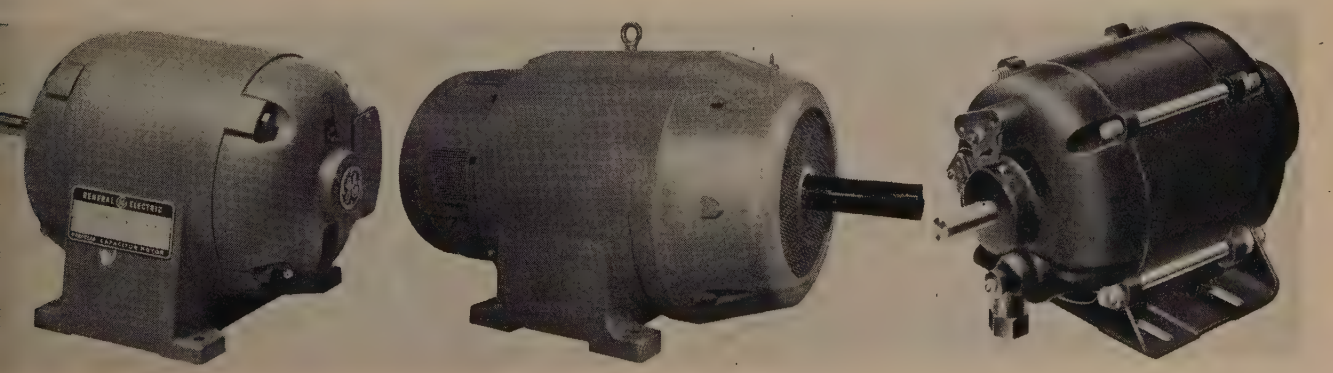


Fig. 25. A multiple drill press equipped with the push-button form of a new manual starter

controlled by the output of two small vacuum tubes. It is designed for temperatures ranging from −65 F to 160 F, in dry or wet atmospheres, and up to 40,000 ft altitude.

Projecting bosses have been eliminated so that a new gasoline-pump motor (FIG. 24) requires less space. A trunnion-mounted base can be used in any one of four quadrant positions.

Hermetic refrigerator motor parts were extended to ratings of 7½-hp polyphase and 5-hp single phase, and two new motor diameters were added in the 1- to 10-hp range.

New two-unit two-bearing motor-generator sets are smaller in size, lighter in weight, and offer greater power output for their size than the superseded design. They are particularly for magnetic chucks, testing devices, and other applications requiring moderate amounts of d-c power. Powered by 3450-rpm single- or three-phase drive motors, they were made available in ratings up to 750 watts at 250 volts d-c.

CONTROL

Direct-current Brake . . . *Fast-acting; Simplified*

A FAST-ACTING spring-set d-c brake of simplified and symmetrical design for holding and stopping, is adaptable for right- or left-hand mounting. A torque-setting indicator provides visual check of foot-pounds torque setting, and a magnet-gap indicator shows at a glance when adjustment is required to compensate for lining wear. The brake wheel can be removed either horizontally or vertically without removing any part of the brake.

Motor Starters . . . *Versatile*

A new line of manual starters for motors up to 7½-hp (FIG. 25) includes open and general-purpose enclosed switches for push-button or toggle operation in 2-, 3-, or 4-pole forms.

A synchronous-motor field control, built for severe industrial use, permits wide load swings before removal of field. Field is applied at a consistently favorable angle, and removed within the first slip-cycle on pull-out without premature removal.

There is a neat family appearance when different sizes of a new line of d-c contactors are arranged on a panel. Rated 25, 50, and 100 amp, they are front-connected, of unit construction, and can be mounted on either compound or steel bases. A corresponding line of d-c magnetic starters maintains the family appearance.

Unit building-block construction with redesigned integral-hp Thy-mo-trol drive permits easier servicing. A new circuit design extends application.

Approximately 25 percent in floor space is saved by a new high-voltage air-break contactor for motors ranging up to 1250 hp, 5000 volts, and requiring starters with high interrupting capacity.

Fig. 26. Monitoring the main oil flame of a commercial oil burner by means of a completely integrated photoelectric combustion control system

Up to 600 operations per minute on duty-cycle applications are possible with the new short-stroke solenoid. It is unusually small and compact, with a 5/16-in. stroke. A Permafil molded coil gives exceptionally long life.

Combustion Controls . . . *And Refrigeration*

Included in a set of components for domestic oil-burner heating systems are: a stack-mounted master control having a bimetal flame detector; a hot-water and limit control with a detachable dry well; a warm-air fan or limit control having a dial indicator for ease in setting; and a group of thermostats operating on low- or line-voltage.

A photoelectric combustion-control system (FIG. 26) protects commercial oil burners against danger inherent in flame failure and the entrance of fuel into a heated combustion chamber. Almost instantaneous closing of the oil valve is assured should flame failure occur. A 30-sec or longer motor-running period after shutdown is also provided.

A smaller, accurately calibrated, voltage-type accelerating relay was designed primarily for control of hermetically sealed refrigerator compressor motors.

epetitive accuracy is high; several hundred thousand perations without appreciable change in calibration re indicated.

Small size and high capacity were combined in a ighly accurate thermostatic cold control for domestic efrigerators. It is easily adapted for use with water oolers, air-conditioning units, and frozen-food cabinets.

ther Controls . . . *Liquid Regulation*

The level of liquid in a sump or wet well now can be gulated automatically by floating a rheostat in the quid and connecting it to the secondary of a wound-otor motor to control the speed of the pump. The oating tank-liquid rheostat tends to maintain a level liquid in the wet well for each value of in-flow to the ell.

A new pressure switch for domestic water systems—nall and inexpensive—is zinc-chromak-finished for rotection against corrosion. It has ample wiring pace, oversized silver contacts for long life, and a leaf-ype toggle spring for positive operation.

A simplified crane-hoist circuit carries heavier loads fely, with lower landing speeds and positive response. here are five distinct speed points in the lowering rection, for any possible load. Automatic acceleration nd deceleration are provided. When decelerating, the rake is not allowed to set until the speed of the ystem has been reduced by dynamic braking—saving rake-lining wear and reducing mechanical stresses on he crane. A 200 percent load on a crane can be lowered ith 85 percent mechanical efficiency, with no tendency r the motor to run away.

A complete instrumentation and control console for he refining industry includes the graphic representa-on of the process on the panel by using miniature rocess indicators and controllers. Multipoint tempera-re recorders and pressure receivers are used to record rmanently the more important variables.

By means of a combination of two types of electronic lays, greater tonnage with resultant lower costs is hieved at the new 12-in. merchant mill of Sheffield eel Corporation. As the oncoming hot rod touches an insulated roll connected to the initiating relay, the kick-off circuit is initiated. A timing relay interposed between the initiating relay and the kick-off motor control compensates for various mill speeds.

The high sensitivity of the electronic relay is also used to protect operators of wire-drawing machines from broken wires or wire ends revolving at high speeds around a winding head. Even the finest of wires striking a screen energizes the relay and shuts down the machine.

Fig. 27. The elevated U-shaped heating chamber of this porcelain-enameling furnace, operating at 1550 F, minimizes convection heat losses

INDUSTRIAL HEATING

Galvanized Steel . . . *Can be Drawn*

GALVANIZED steel of such high quality that it can be bent, rolled, and, to some extent, drawn without cracking or flaking the zinc is being produced in a continuous annealing and dry-pickling furnace at the Irvin Works of Carnegie-Illinois Steel Corporation.

The motors, generators, and control equipment were supplied for the new tower furnace, rated 2036 kw with a nominal output of 10 tons per hour.

The heavy-gage line has a roller-hearth horizontal furnace with a 1400-kva 9600-cycle induction preheat, followed by a 375-kw conventional electric furnace and an automatically regulated cooling chamber. Both lines take coiled steel directly from the cold-strip mills.

Aluminum Brazing . . . *Where Temperature is Critical*

Reactrol control was included in several mesh-belt conveyor-type furnaces where maximum temperature uniformity is needed—in brazing aluminum evaporators for home freezers and two-temperature refrigerators. Three of the furnaces are rated 176 kw, and the fourth 225 kw. All operate at about 1185F.

Enameling Furnaces . . . *Largest*

Two porcelain-enameling furnaces installed at the Kaiser Fleetwing plant in Bristol (Pa.) are of particular interest not only because one is the largest electric counterflow type ever built but also because incoming parts are preheated by the outgoing hot work, providing lower operating costs and reducing warpage. The furnaces (FIG. 27), used to porcelain-enamel bathtubs and kitchen sinks, are of counterflow heat-sealed type. The larger is rated 1855 kw; the other 1200 kw.

Heater—Speaker . . . *For Drive-in Theaters*

To extend their season, some drive-in theaters are now providing heat. Combined in same unit containing the speaker is a 250-watt Calrod tubular heater formed in a circle, against which a fan sends the air to be warmed and circulated throughout the automobile. It is a product of Theatrecraft Manufacturing Corporation, Cleveland (Ohio).

Induction Heaters . . . *Flexible Design*

A 5-kw induction heater was designed to operate from 230 or 460 volts, 3 phase, 60 cycles, without

changing components. Thyratron control is provided for varying output power. Flexibility of operation is provided by having either work coils or a radio-frequency output transformer for coupling to the load. The oscillator is enclosed, and the rectifier has natural ventilation to reduce accumulation of dust and metal particles.

WELDING

Arc Welding . . . *Gas Saver*

A WATER and gas control for inert-arc welding automatically shuts off the flow of shielding gas and cooling water at a predetermined time after welding is stopped, saving a large proportion of the gas otherwise wasted. The equipment, designed with standard components, includes separate solenoid valves for gas and water, adjustable time-delay feature, and fail-safe characteristics.

Silicone insulation exclusively is used in a lightweight diesel-driven d-c welder for shipboard service. Other features are its low weight, radio-noise suppression, and shock-proof-type design.

A water-cooled engine is a feature of a NEMA 200-amp engine-driven d-c welder. It is light in weight, compact in dimensions, has hand cranking, and employs a simple slow-down control for reduced-speed idling.

Electrode holders for both atomic-hydrogen and inert-arc welding processes were made lighter and easier to maintain, in both 50- and 100-amp ratings. The inert-arc electrode holder (FIG. 28) has a metal gas nozzle which is water-cooled without external water connections. Its tip is easily replaced at low cost, it reduces the consumption of shielding gas, and it contributes to the unusual visibility characteristics of the holder.

Resistance Welding . . . *New Applications*

Three-phase resistance welding control was applied in seam and spot welding of aluminum parts for aircraft. The control has been qualified under government specifications ANW30 for welding aluminum and its alloys, and under ANW32 specifications for steel and stainless-steel welding.

Slope control, which electronically varies the welding current gradually from an initial low value during the formation of the weld, was applied in conjunction with single-phase resistance-welding control in the projection welding of stainless-steel parts of jet engines. It has also proved successful in the welding of Inconel; many more applications are expected.

POWER ELECTRONICS

Amplistat Application . . . *Completely Static*

THE amplistat, a magnetic amplifier reactor, was applied during the year to power rectifiers for constant-voltage control and for adjustable-voltage electronic d-c motor drives, used principally in printing-press equipment. The amplistat (FIG. 29) is a completely static device having no contacts or moving parts, and is sturdy and simple in construction. Little maintenance is required, and life span is long. It provides a high ratio of output power to control power, and gives electric-circuit isolation. In power electronic applications, use of amplistats has reduced the size of component equipment.

Magnetic amplifiers were applied to rectifiers because of greater emphasis placed by users on reliability of operation over extended periods of time in difficult service conditions. Recent improvements in magnetic materials and in metallic rectifiers, which are component parts of the amplistat, have led to substantial advances in amplifier performance.

Fig. 28. This 400-amp inert-arc electrode holder weighs only 26 oz, including four feet of cable and hose

Nuclear Equipments . . . *Problems Imposed*

Many of the new tools in the field of nuclear research, including the pulsed betatron and the synchrotron, require appreciable amounts of power and impose unusual control problems. High-voltage ignitron contactors (FIG. 30) have been installed in three university laboratories to provide large amounts of controlled peak power for magnet excitation of such devices.

The synchrotron requires a time-varying magnetic field throughout the ring-shaped region containing the orbit in which the electrons are to be accelerated. This varying magnetic field is obtained by discharging a large capacitor bank through the magnet windings and then interrupting the oscillatory discharge after one full cycle of current flow. The discharge can be controlled by two groups of pentode-type ignitrons connected in inverse parallel so as to conduct current in either direction as required. Pumped ignitron rectifiers—developed for high-voltage service—are being used for controlling the discharge from a large capacitor bank into the magnet coil of a pulsed betatron.

Electronic D-c Motor . . . *Printing-press Drive*

Wide application was made during the year of adjustable-voltage sealed ignitron rectifier units in

o-ordinated printing installations. The new drive has he basic advantage of a d-c motor in an adjustable-oltage control system; most conventional drives make se of wound-rotor induction motors with secondary esistance control and, to a limited extent, adjustable l-c motors with armature resistance and field control. The press motors have a 2:1 field range, which corre-ponds to the usual operating range required on a press. Jnder emergency conditions, if a motor is lost from a ombination, those remaining can carry the torque at stronger field and at reduced speed.

Adjustable-voltage Rectifier . . . *Tube Tester*

A large adjustable-voltage rectifier—complete with protective switchgear and master and load-center unit ubstations for power supply—was produced for testing igh-power radio transmitter tubes. The rectifier is ated 1000 kw at 17 kv and 1500 kw at 10 kv, the dual ating making possible a wide variety of voltages for esting purposes. Six sealed ignitrons are used in a hree-phase double-way circuit. The ignitrons, of new ype, are rated 50 amp average current, 20 kv inverse, nd are similar to the large ignitrons in successful ommercial use.

Testing of expensive high-power vacuum tubes equires that any fault in d-c power supply arising rom defective tubes, or from tubes not yet fully rocessed, must be cleared in a short time interval to revent excessive damage to the tubes. Use of the new gnitron makes possible exceptionally high-speed d-c ault clearing by means of arc suppression.

WATER AND SEWAGE

A VERTICAL raw-water pump installed for the city of Waco (Texas) during the year has a new type a-c djustable-speed drive. It operates at relatively high fficiencies over the complete speed range of the motor.

The drive, designed for use where variable pumping equirements are encountered, utilizes a standard ound-rotor motor and a brush-shift (ohmic drop) xciter mounted in tandem. Although the drive was developed to fill a need for an a-c adjustable-speed drive for sewage and water pumping in ratings from about 150 to 500 hp and moderate speed ranges, its application is not limited to pumping.

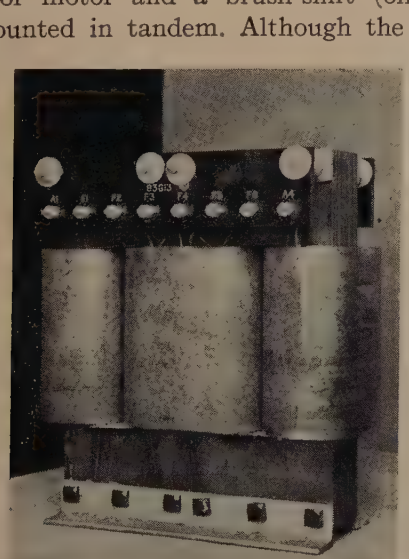


Fig. 29. The amplistat, a magnetic amplifier reactor—completely static, extremely sturdy, and of simple construction

COAL HANDLING

A NEW coal pier handles increased coal-loading demands at Newport News (Virginia), especially in speeding foreign shipments. The concrete pier extends about 1063 ft beyond the Chesapeake and Ohio bulk-head line and provides sufficient space to accommodate four ships, two on each side.

The pier is served by two duplex rotary-type car dumpers, each with a capacity of dumping two 70-ton

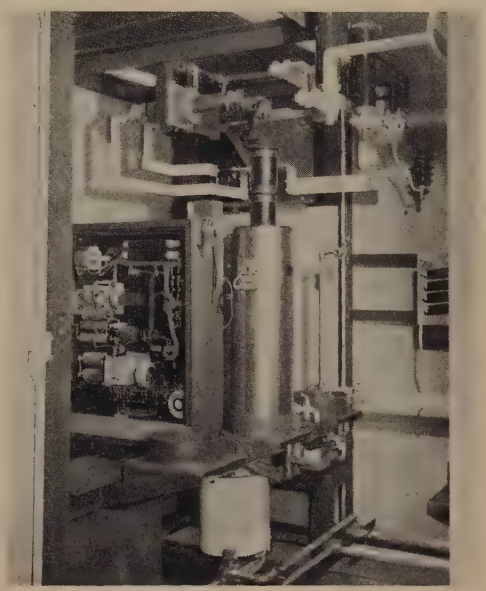


Fig. 30. A 17-kv 6000-amp ignitron contactor for use with a synchrotron in nuclear research

cars of coal every two minutes. Each duplex dumper in turn feeds two main belt feeds to a travelling-type loading tower. Four ships can be loaded simultaneously, or the two loading towers on either side of the pier can load a single ship. Each main belt has a capacity of 1500 tons per hr.

A pusher head rolling on narrow-gage tracks inside the standard-gage coal-car tracks supplies each duplex dumper with two loaded cars at a time. The pusher head, or mule, is attached to a hoist-drum-driven cable system. The loaded cars roll up a 15 percent grade onto the dumper cradle, bumping off the empty cars. The storage areas care for 800 loaded and 640 empty cars.

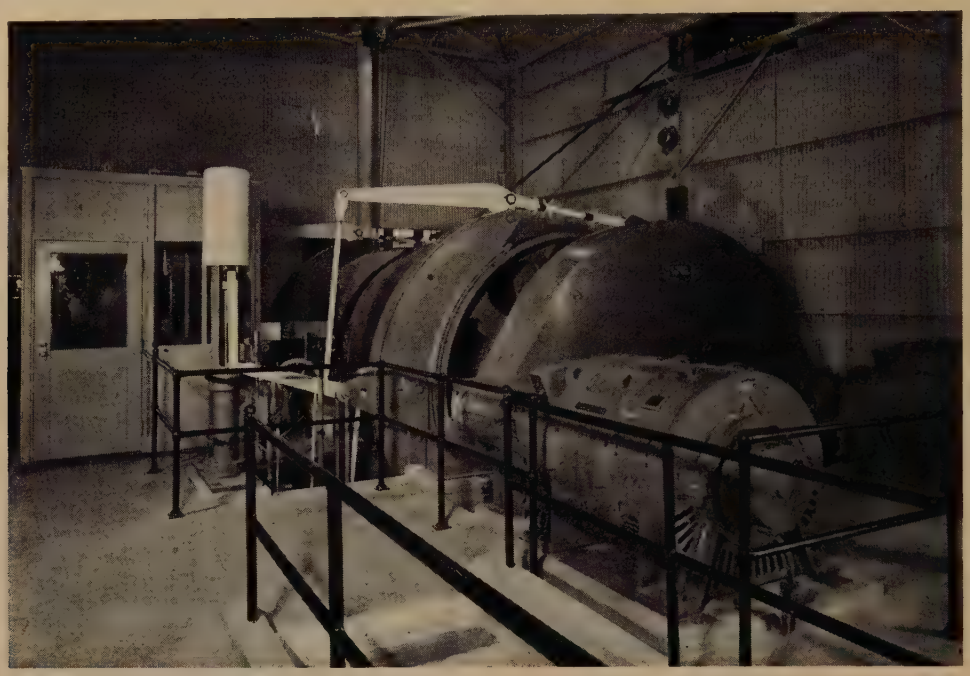
An idea as to the magnitude of the installation is given by the list of electric equipment. There are a 4000/5000-kva outdoor master unit substation and six 500-kva outdoor load-center unit substations, and two 900-hp synchronous motor starter metal-clad switch-gear units. The mule hauls utilize two 4-unit motor-generator sets, four mill-type motors, and two adjust-able-speed controls including motor brakes. The car dumpers require four 60-hp motors, brakes, and

control; two 7½-hp air-compressor motors and control, and four controls for car spotters.

The belts need 28 motors and control from 15 to 125 hp each. The loading towers have four 200-kw synchronous motor-driven motor-generator sets and control, and 44 motors and control from 6½ to 135 hp each.

MINING

SPECIAL push-button drive and control equipment has enabled a new mine hoist at Carlsbad (New Mexico) to raise and dump 8 tons of potash ore per minute from 1150 ft below ground, and to do it automatically. Installed at the Potash Company of America mines, the new hoist will speed production of potash for fertilizer, so essential in maintaining a high level of food production.



A double-drum ore hoist driven by two d-c motors each rated 500 hp

Driven by two 500-hp motors, the hoist alternately sends two ore buckets, or skips, down the 1150-ft vertical shaft, waits long enough for a bucket to be filled by a gravity chute, and starts upward with the 8-ton load. Meanwhile, the other bucket has automatically dumped its load of ore and is on the way down to repeat the cycle. Full-hoisting speed is 1500 ft per min, but the control system automatically decelerates the hoist as the buckets approach either end of the lift, to prevent overspeed and overtravelling.

Ore hoisting is normally carried on automatically, but a hoistman is on duty to initiate the starting and stopping of the day's production or otherwise direct the hoist's movements when necessary.

LUMBER

A YEAR of operation has shown that use of amplidyne-control with a veneer lathe drive has speeded up lathe operation, reduced waste, and improved the quality of the veneer. The control supplied to a West Coast plywood company was superimposed upon the existing d-c drive motor and generator. When a break occurs in the log (and breaks can be frequent), the operator quickly stops the drive, releases the pressure on the pressure bar, runs the log back about a foot, cuts out the bad spot, and begins peeling again. It is not necessary to disengage the knife mechanism; thus the veneer thickness is on gage as soon as the knife starts peeling again.

Separate amplidyne exciters are used for both the generator and motor fields. Both armature-voltage and motor-field control are used to cover the required range of speed and torque. The drive was basically designed to hold constant veneer-cutting speed for any log diameter.

PAPER

Beta-ray Gage . . . *Weighs Moving Sheet*

PAPER-MAKERS now can measure paper weight on a moving sheet by means of the beta-ray gage—and can make the measurement automatically and continuously. The detector head can even be made to scan across the width of the sheet, without even touching the paper.

Tensiometer . . . *Holds Preset Value*

A simple tensiometer now monitors tension accurately, continuously, and automatically. When used with standard speed-regulated sectional drives, it injects a signal into the control system, thus holding preset tension in the paper automatically, regardless of variations in drying, machine loading, or stock condition. The equipment, consisting of a tensiometer head and magnetic control cabinet with indicating instrument, is sturdily constructed to withstand hard paper-mill usage.

TEXTILE

huttle Detector . . . *Promises More Speed*

IN CO-OPERATION with Crompton & Knowles Loom Works, there has now been developed an electronic huttle detector which, in conjunction with dynamic raking control, has been successfully applied to large lt looms to ascertain when a faulty shuttle flight occurs nd to stop the loom before there is resulting damage o the fabric. Formerly, mechanical stops were used.

The equipment consists of two coils with cores onnected by a bar magnet, a rotary switch, and a nall control panel. The coils are imbedded in the ay; the switch is coupled to the loom topshaft. The lectronic circuit is, in effect, a switch which closes as result of the signal transmitted to it when the shuttle, n which a soft iron plate is embedded, passes over the oils. This electronic switch is connected in parallel with he rotary switch, and the two switches are together in eries with the braking control.

During the sixty-degree interval in which the rotary witch is open, the electronic switch must be closed signifying proper shuttle travel) for the loom to ontinue to operate. If the shuttle is late in its flight for ny one of several reasons, opening of the rotary switch nterrupts current flow to the braking relay and the irect current is applied to the driving motor. The device rovides detection early in the loom lay cycle, and at a oint where stored energy is low.

arn Tensiometer . . . *For Spinning Frames*

Measurement of yarn tension under true spinning onditions is provided by a new tensiometer, useful in tudying the many factors affecting yarn tension such s size and condition of travelers, ring-rail position, iameter of yarn package, and spindle speed. The quipment is expected to become a vital instrument in extile research and development work.

The tensiometer transforms the yarn tension into an lectric signal by means of two standard magnetic train-gage coils and the usual 60-cycle 110-volt power-upply unit. Yarn guides and a restraining beam are ttached to a shaft so that yarn tension causes a pro-ortional deflection of the beam. When the beam is eflected, the air gaps between it and the coils change, ausing an output signal by reason of the unbalanced train-gage circuits. The signal is fed into a photo-lectric recorder or similar instrument. Tension of one o 10 ends can be measured at once.

MACHINE TOOLS

laner-miller . . . *Fast, Smooth, Versatile*

ELECTRONIC and amplidyne-controlled drives have given a large planer-miller (FIG. 31) unusual ersatility; despite its size, it is easily controlled by one perator. As a planer, it has fast smooth reversal of peed ranging from 80 to 1200 rpm. Control is by a generator whose excitation is supplied from a 3-kw amplidyne generator which in turn is electronically controlled from small rheostats on the operator's pendent push-button station. When the machine is used as a miller, controls of table-feed speed and spindle speed are likewise easily adjusted from the operator's pendent control station. A 15-hp Thy-mo-trol drive is used for table motion over a 45:1 speed range. Milling cutters on the rail head are each driven by a 50-hp adjustable-speed motor supplied from adjustable-voltage generators, each provided with controlled excitation from electronic exciters. Feed drives for the milling heads are controllable over a 100:1 speed range through use of Thy-mo-trol drives, which are also easily controlled from the pendent station.

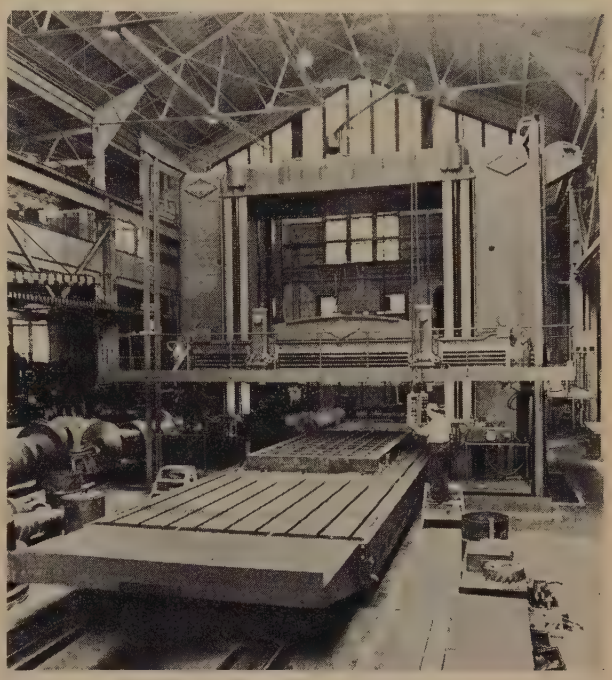


Fig. 31. Electronic and amplidyne-controlled drives make this huge planer-miller truly versatile

Transfer Press . . . *Production Up, Cost Down*

Use of a large transfer press with multiple dies to perform successive operations in the same machine yields considerable savings in cost and increased production, compared to using single presses with work-handling fixtures in between. Using amplidyne generators with magnetic control has provided a most flexible and accurate means for driving the clamping and feeding motions of a large transfer press (FIG. 32). The d-c motors driving these motions are accelerated smoothly under current limit to preselected speeds, and then decelerated in response to signals from limit switches mounted on the press.

Electronic Controls . . . *Extended Applications*

Electronic controls—adding to versatility and productive efficiency, and contributing to cost reductions—continued to provide an answer to drive and control problems on both the existing and new designs and

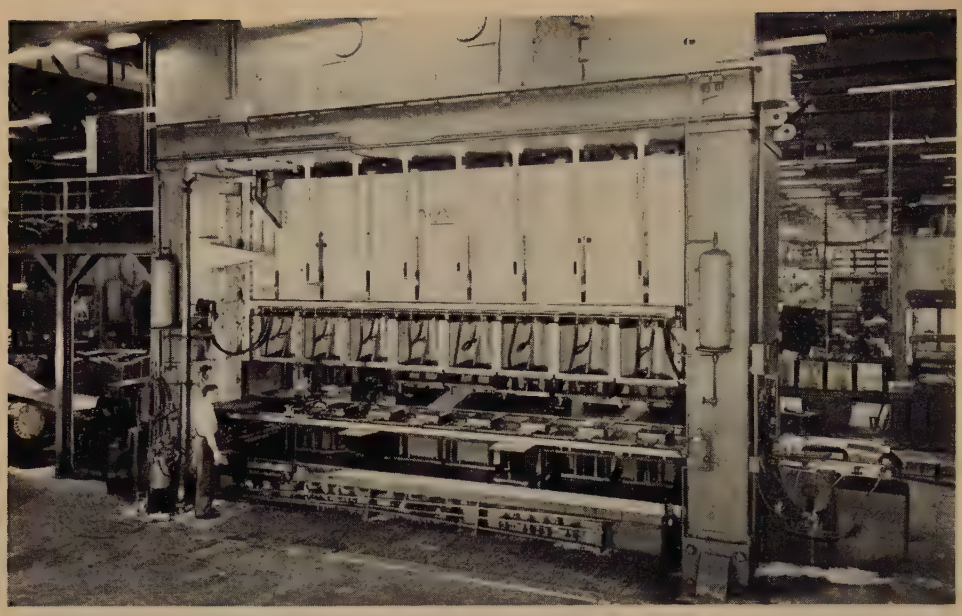


Fig. 32. Clamping and feeding motions of this transfer press are accurately controlled by means of amplidyne generators with magnetic control

machines. Not only the metal-fabricating but also the woodworking and wire industries found increased use for controls combining the amplidyne with other magnetic and electronic circuits.

The table of a wood-carving machine is accurately and smoothly reversed by a single-package combination of electronic control and amplidyne generator. Coil-winding operations in the electrical industry have been speeded up by a similar control; and in another instance the rate of feed of large grinders is controlled automatically, thereby utilizing to the fullest extent the horsepower available in these machines by regulating the load on the grinding wheel.

Contour Follower . . . *Optical*

A new optical contour-following system (FIG. 33) controls a machine tool which machines sections directly from a metal plate on which a fine-line drawing has been reproduced. A microscope-lens system forms an enlarged image of the line on an aperture plate, and the image is made to rotate by means of an optical prism. As the rotating image of the line sweeps over a stationary small hole in the aperture plate, a phototube detects the cyclic changes in light intensity and converts them to electrical pulse signals. These signals control the positioning of the machine tool. The scanning mechanism follows the line to within 0.003 in. Since the drawing can be large, and reduction of size varied from 3.75:1 to 60:1, system accuracy exceeding 0.001 in. can be expected. The equipment has not been applied to ordinary machining processes, but it is expected to find application in fields where small quantities of relatively expensive pieces must be produced to close tolerances.

STEEL AND OTHER METALS

Amplistat . . . *A Reality*

DURING the year many electrical advancements became realities in the rolling and processing of steel and other metals. One was the amplistat, technically known as a self-saturated magnetic amplifier and representing the latest advance in amplifiers for regulating circuits. It has great appeal for steel-mill operating and maintenance men because of its simplicity, lack of moving parts, and absence of components requiring maintenance.

The amplistat was successfully used in conjunction with the amplidyne to maintain steel strip at a predetermined level in the pickling tanks of a new 66-in. high-speed pickling line. It also successfully demonstrated its ability to operate in conjunction with the amplidyne in a closed-cycle regulating system used to hold tension on the winding reel of the world's fastest cold-strip mill.

An 86-in. hot-strip mill has been installed with two 5000-kw 600-volt mercury-arc rectifiers supplying adjustable voltage to the finishing-stand motors (FRONTISPIECE). The amplistat will regulate bus voltage and provide suitable load division between the two rectifiers.

Fig. 33. This optical contour-following system follows a fine-line drawing with a machining accuracy of a mil

ot-strip Mills . . . *First in Years*

Successful operation of the first new reversing hot-rip mill to be installed in this country for many years as awakened new interest in this type of mill. Other milar mills are being installed or are in the process of anufacture both in this country and abroad. These ills require great operating skill and the best in elec-ical equipment for successful performance.

old-strip Mills . . . *Several More*

The individual generator system of control was used r the successful operation of five tandem cold-strip ills which are now in production. Three more such ills are in the process of manufacture. One of these for shipment to Europe, and the other two for omestic use. One of the latter is a 2200-fpm 75-inch -stand sheet mill; the other is a 54-in. 4-stand sheet ill with a rated speed of 3000 fpm.

type control. One such mill placed in service during the past year has a reversal time of 1.2 sec from base speed to base speed. This is a 40-in. reversing blooming mill with a 6000-hp, 40/100-rpm twin drive (FIG. 34). A duplicate drive has also gone into service with essentially the same speed of reversal. In addition, two reversing blooming mills are being manufactured for Europe. One of these, a 44-in. mill, will be powered with an 8000-hp, 50/120-rpm twin drive. The other, a 36-in. mill, will be driven by a 5000-hp, 50/100-rpm twin drive.

The electric drive for the world's largest plate mill was manufactured during the year. This 206-in. reversing plate mill was formerly driven by a steam engine, now replaced by the largest twin drive ever manufactured. These twin motors have a continuous rating of 8000-hp, 30/75 rpm and will be supplied with power by a flywheel motor-generator having four 1750-kw generators.

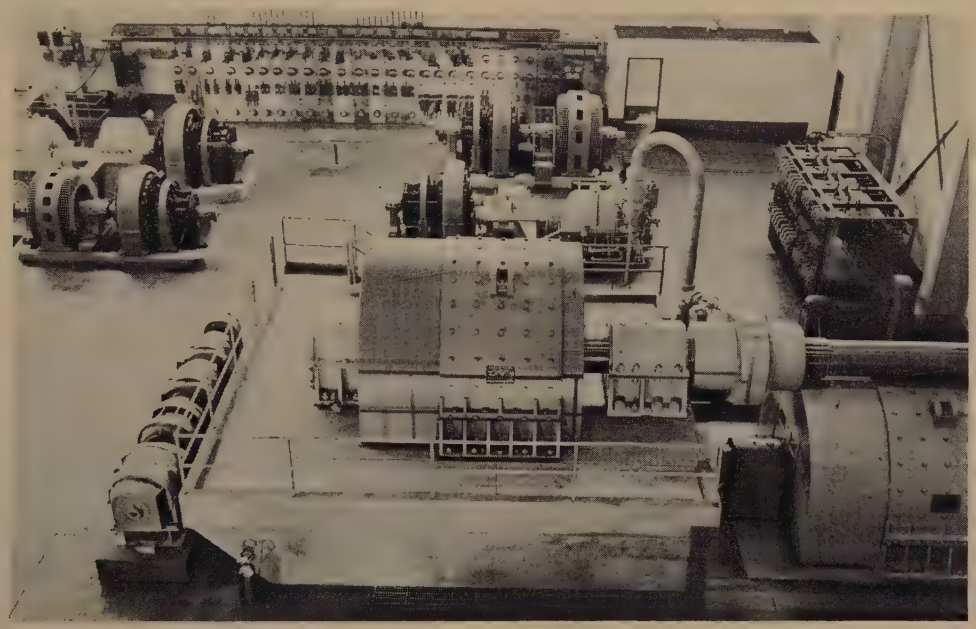


Fig. 34. A 6000-hp drive for a 40-in. reversing blooming mill

The electrical equipment is being built for three endzimir mills, the largest of which is driven by a 150-p main motor and two 150-hp double-armature reel otors. One of the largest reversing cold-strip mills ver built is under construction for Belgium; it will be combination sheet-and-strip mill with a 3000-hp ain drive and two 1000-hp reel drives.

The success of a reversing cold-strip mill installed veral years ago with twin drives on the back-up rolls as been so pronounced that a larger mill is under con-ruction. This mill is a 4-high mill with relatively nall working rolls and a 100-hp, 460/500-rpm drive otor direct-connected to each back-up roll. A 150-hp ouble-armature motor is used for each winding reel.

ther Rolling Mills . . . *Faster Reversal*

Amplidyne control for reversing mills—first supplied a 35-in. structural mill rougher in 1938—has now een adopted by 39 mills. Of these, 32 have been new ills and seven have been changeovers replacing old-

A 42-in. 5000-fpm two-stand temper mill placed in operation during the year uses amplidyne control on the pullers and reels and a regulating tensiometer between the stands, giving exceptionally smooth operation.

Two continuous rod mills, for shipment abroad, will use specially designed low-impact speed-drop d-c motors on the main stands, with amplidyne adjustable-voltage control. One of these mills is unusual in that the finishing stands are individually driven by d-c motors rather than having a group of stands connected to one motor.

A tandem billet mill, also for foreign shipment, will have eight tandem stands—the first two driven by one 1500-hp d-c motor and the last six geared together to one 7000-hp a-c motor. The 7000-hp motor in effect drives the whole mill, since it is coupled to a 1500-kw d-c generator which supplies power to the 1500-hp motor.

One of the fastest aluminum-foil mills ever built went into successful operation; it is a 4-high mill with a rated speed of 3000 fpm and is driven by a 750-hp main

Fig. 35. A 100,000-volt x-ray thickness gage as mounted for use in continuous hot-strip steel mill

motor. Four similar high-speed foil mills are under construction for shipment to France. All have a top speed of approximately 3000 fpm.

Processing Lines . . . *Precise Operation*

Significant developments have taken place in the field of processing lines with the purchase of a number of high-speed sheet-shearing lines and the successful operation of a continuous light-gage galvanizing line. This 48-in. continuous galvanizing line (and a duplicate line now under construction) have a speed range of 50 to 300 fpm. Tower-type, multiple-pass electrical furnaces provide the necessary heat for annealing and galvanizing. Adjustable-voltage control with amplidyne regulators and modulated loop controls provide the precise operation which is necessary in a process of this kind.

Several high-speed doubling and separating lines have gone into operation in the aluminum industry. These foil-processing equipments have a maximum speed of over 5000 fpm.

X-ray Gages . . . *And Rectifiers*

A 100-kv x-ray gage (FIG. 35) measures the thickness of strip as it emerges from the finishing stand of a continuous hot-strip mill. Operators are now able to correct strip thickness as the coil is being rolled. Seven gages have been manufactured for this purpose, and more are being built. A similar gage is being used on an aluminum hot-strip mill.

Copper-oxide rectifiers were used as a source of low-voltage d-c power for electroplating. Two large installations for electrolytic galvanizing were made during 1949. Each installation utilizes 75,000 amp at 10 volts d-c supplied by fifteen 5000-amp metal-enclosed forced-ventilated units. Air-to-water heat exchangers are mounted in each unit to carry away the heat.

FARM INDUSTRY

Crop Drier . . . *Multijet*

THE finished drying of farm crops—hay, corn, small grains, soybeans, peanuts, rice, etc.—is recommended and being promoted actively by the U. S. Department of Agriculture and leading agricultural colleges as an economic necessity in machine-age farming.

During the year the Habco Manufacturing Company, Columbus (Neb.), introduced its Jet-Dry crop drier (FIG. 36). The electric components, all of General Electric manufacture, include a new multi-air-jet burner giving clean heat, as well as the motor, control, ignition transformer, and protective equipment.

Heated Brooder . . . *Above and Below*

Baby chicks can now be given the best of care with a warm, dry bed beneath and a radiant-heat blanket over their backs. Heating cable buried in the cement floor keeps the floor comfortably warm and the litter dry, important as a health factor. Supplemental heat for maximum comfort is provided by overhead 250-watt infrared heat lamps. Chicks brooded this way (FIG. 37) grow and feather rapidly, with low mortality.

Calf Dehorner . . . *Quick, Sure*

Calves can be dehorned quickly, easily, less painfully, and more surely with an electric hot-iron. There is neither bleeding nor open sores; the horns simply drop off about a month after treatment. The dehorner is a standard 300-watt industrial soldering iron with a special hollow-cone tip; in fact, a 1¼-in. diameter soldering tip is included for interchange.

Fig. 36. Machine-age farming calls for crop driers

Fig. 37. These chicks are warm, and do not crowd. There is heating cable in the concrete floor and infrared lamps overhead

olley coach at the summit of a 19-percent grade in San Francisco

TRANSPORTATION

AVIATION

opulsion . . . *More Power*

A BOEING XB-47 Stratojet bomber set a new coast-to-coast speed record of 3 hours, 46 minutes uring the year—about 607 miles per hour in a 2289-ile flight from Moses Lake AF Base (Wash.) to ndrews AF Base (Md.). The plane was driven by six eneral Electric J-35 jets. A G-E propelled F-80 Shoot-g Star had held the previous record, set in 1946 with n average speed of 588 mph. After establishing the ew record, the Stratojet was equipped with the even ore powerful J-47 turbojets (FIG. 38), giving the XB-twenty-five percent more total power. The J-47's e being used in the production version of this aircraft. The J-47 is also being used in a number of other U.S. ir Force fighters and bombers, including the F-86 abre, holder of the world's official speed record of 0.981 mph; the B-45 Tornado bomber; the Air Force's ewest interceptor, the XF-91, which also has rockets r accelerated take-offs and operation at high altitude; nd the huge B-36, world's largest land-based bomber, hich will use four J-47 turbojets to supplement six ston engines.

Newest jet plane announced by the Air Force as ing powered by the J-47 is the three-jet XB-51. This eek bomber is designed to give tactical air support to ound forces. Built by Glenn L. Martin Co., the XB-(FIG. 39) carries two of its jets mounted under the ng and the third in the tail.

The J-47, already the most powerful jet engine in oduction in this country, underwent marked im-ovements during 1949. Anti-icing tests atop Mount ashington during the winter and in-flight tests on a 47 slung from the fuselage of G.E.'s B-29 Flying aboratory, operating out of Schenectady, led to the velopment of the J-47 as the first all-weather jet gine in the country. Design refinements have so improved the performance of the engine that it is now rated by the Air Force as being capable of producing "more than 5200 pounds of thrust."

The first aircraft jet engines produced at General Electric's new Lockland Plant were shipped to the Air Force in February during special ceremonies. With more than 200 subcontractors furnishing all component parts, production at the Ohio plant marks a new development in the aviation industry. While the Company will continue to manufacture parts for the J-47 engines built at Lynn (Mass.), all parts of the Lockland-assembled J-47 will be produced by subcontractors throughout the country.

Turbosuperchargers . . . *Commercial Use*

Although the emphasis, from a military standpoint, has been foremost on jet propulsion, a considerable amount of work has been directed toward a compound reciprocating-engine system including three turbo-superchargers and a comprehensive control system for the entire power plant. The work may well have future applications in the field of civil transport airlines.

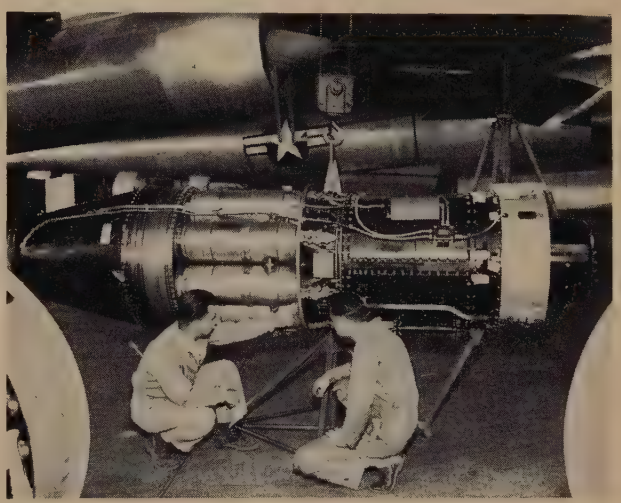
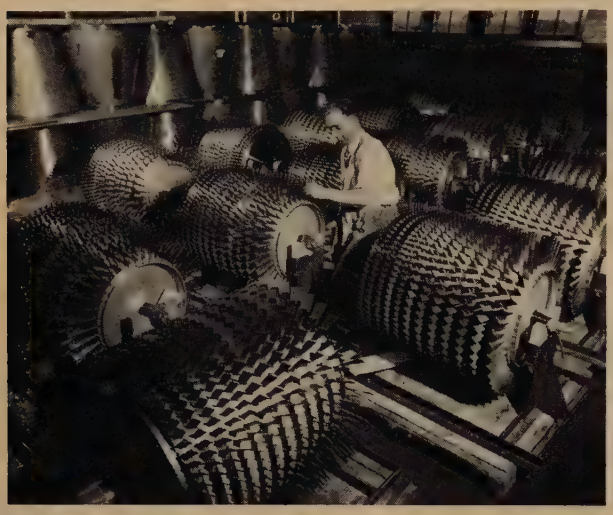


Fig. 38. Boeing technicians checking a J-47 jet engine prior to its installation in the XB-47 Stratojet

Fig. 39. The radically designed Martin XB-51, the U.S. Air Force's three-jet bomber, is powered by G-E jet engines. The three engines provide over 15,600 lb of thrust

During 1949, the co-operative development between G-E and Pratt & Whitney on advanced piston-engine turbosupercharger cycles reached a conclusion in the initial phase of this program with the completion of the VDT (Variable Discharge Turbosupercharger) power-plant development. The CHM-2 turbosupercharger and the variable discharge nozzle were developed to supply full-engine manifold pressures. Ground and flight testing of the VDT power plant substantiated the original estimates of greatly increased power and lower fuel consumption made early in the program.

The year marked the first successful introduction of an exhaust-gas-driven turbosupercharger in commercial-airline operation when the first Boeing Stratocruiser was placed in operation. Each of the Stratocruiser's four Pratt and Whitney engines is equipped with a BH-4 turbosupercharger.



Not really cacti—these are compressor rotors, major parts of powerful aircraft jet engines

The flight recorder in the B-29 Flying Laboratory automatically records air roughness, altitude, and operation of automatic pilot and de-icing equipment on aircraft

BH-1 turbosuperchargers are being used in the giant B-36 bomber. They enable the engines to maintain adequate power to well over 40,000 ft, besides providing cabin comfort at extreme altitudes. Turbosuperchargers will be used similarly in the production versions of the B-50 bomber.

Electric Components . . . *Ever-increasing Load*

With the rapid growth of electrical load on both civilian and military planes, it has been necessary to give greater and greater attention to the complex electric equipment. Methods of system test and analysis generally similar to those used in utility power-station practices have been applied. New protective devices have resulted, and ways of system regulation and distribution have been determined and are being put into effect.

A new circuit breaker was introduced to provide adequate interrupting capacity at all altitudes up to 50,000 ft, together with suitable tripping characteristics for the various types of systems encountered. The breaker was made available for both 28- and 120-volt d-c service in ratings up to 600 amp continuous, with interrupting ratings of 12,000 amp at 28 volts or 5000 amp at 120 volts.

A fast-acting generator-voltage regulator for d-c aircraft generating systems maintains constant-output voltage within $\pm 2\frac{1}{2}$ percent through wide speed, load, and temperature variations. It is compact and dust-tight, and has a large fin area for greater heat dissipation. Voltage is readily adjusted between 26 and 30 volts and, once set, will remain fixed. An equalizer winding provides for equal load division between generators operating in parallel.

A portable heavy-duty aircraft energizer was specifically designed to provide regulated $28\frac{1}{2}$-volt ground power for starting all types of reciprocating engines as well as adjustable-voltage power for starting jet engines. The energizer is equally desirable for supplying electric power to aircraft before take-off, for use in shops and hangar repair areas, and for facilitating production tests on jet engines and aircraft. Supplementing this heavy-duty 500-amp energizer was a lighter-weight energizer, rated 265 amp and 7.5 kw, for medium requirements of low-voltage d-c power supply.

Test Equipments . . . *Tunnels, Etc.*

Installation was completed on a new wind tunnel at the University of Maryland's new Glenn L. Martin College of Engineering and Aeronautical Sciences. The tunnel's drive system consists of a 2250-hp synchronous motor powered by an induction frequency changer and controlled by a generator-field control system on the frequency-converter drive. A powered-model system affords speed control for motors, located within aircraft models, which simulate slipstream effects by rotating scale propellers.

A "human centrifuge," which will duplicate on the ground forces felt by pilots of high-speed aircraft, was nearing completion at the Naval Aviation Medical Laboratory at Johnsville (Pa.). Driven by a 4000-hp vertical motor, the centrifuge will whirl a gondola at the end of a 50-foot arm, developing forces up to 40

times the gravitational pull of the earth. It will be used to study the effects of acceleration and changes of direction on men and instruments.

New facilities were installed at Schenectady for testing turrets for Air Force bombers. Supplementing tests performed at Burlington (Vt.), where turrets are manufactured, the new test center includes a "cold box" in which turrets are subjected to temperatures as low as −65 F, normal temperature at about 40,000 ft.

Six adjustable-speed drive equipments are being furnished the U.S. Air Force for testing aircraft generators in a system equivalent to a six-engined airplane. Each of the drive equipments is rated 350 hp.

Missiles . . . *Two-step Rockets*

A signal advance was made in the development of guided missiles on February 24, 1949, when the first successful two-stage rocket was launched at White Sands Proving Ground. This two-step rocket was composed of a German V-2, rebuilt in this country, and an American "WAC Corporal." The flight established new altitude and speed records of 250 miles and 5000 mph. The altitude reached was more than twice the previous record of 114 miles and the speed was nearly half again as great as the previous record of 3500 mph, established by German V-2's.

The "WAC Corporal," attached to the nose of the V-2, was expelled from the "mother" rocket by remote control at an altitude of 20 miles. It continued upward and, according to Ordnance officers, at the peak of its flight was outside the earth's atmosphere for all practical purposes.

The General Electric group was assisted in this test by California Institute of Technology, Douglas Aircraft Company, and the Ballistics Research Laboratory of Aberdeen Proving Ground.

G.E. supplied vital parts for 15 V-2 rockets, and rebuilt and supervised the firing of them during the year. These were used for scientific purposes by various laboratories and government agencies. A number of static tests have been run on the first complete rocket-powered test vehicle designed by this group.

MARINE

OF THE 31 tankers and supertankers completed during the year, the propulsion turbines or gears of thirteen, totalling 169,500 hp, and the ship's-service turbine-generator sets of eleven, totalling 6700 kw, bore the General Electric nameplate.

The propulsion turbine units on the majority of these tankers (FIGS. 40, 41) use steam at 835 lb per sq in. and 840 F. This, a step ahead for economy, has led to contracts for propulsion geared turbines to operate at still higher temperatures. The ship's-service turbine-generator sets use steam at the same pressure and temperature as the propulsion units, thereby increasing the economical operation of these tankers. Two 400-kw turbine-generator sets supply a-c power for the lights and motors of the majority of the tankers.

Two modern diesel-electric ferries, built by the John H. Mathis Co. at Camden (N. J.), were placed in service by Norfolk County (Va.) Ferries. The two new ferries replace three steam-operated ones.

The Texas Highway Department will operate between Galveston and Point Bolivar two new ferry boats

Fig. 40. Another supertanker, the *Esso Montevideo*, is launched at the Newport News Shipbuilding and Dry Dock Co. yard. It is powered by 12,500-hp geared turbines and has speed in excess of 16 knots

being built by the Galveston Division of Todd Shipbuilding Corp. The 1350-shp vessels will each have two 540-kw generators and two 690-hp geared propulsion motors, as well as two 830-hp Cooper-Bessemer diesel engines. The ferries are intended particularly for vehicular traffic, so passenger accommodations will be limited.

Fig. 41. Swinging aboard the 175,000-lb double-reduction-gear unit of one of the new Standard Oil Co. (New Jersey) tankers. It translates the 12,500 hp from the high speed of the turbine to the 112 rpm for the propellers

The USS *Salem*, last of a trio of heavy cruisers, was delivered to the Navy from the Quincy Shipbuilding Division of the Bethlehem Steel Co. The 30,000-hp propulsion turbines for it and its predecessors, the USS *DesMoines* and USS *Newport News* (FIG. 42), were all built at Schenectady. These vessels are the heaviest and most powerful "heavy" cruisers afloat.

Horsepower-hours . . . *Efficiency Check*

A marine shaft-horsepower-hour meter was designed to measure the horsepower-hours transmitted by a propeller shaft of turbine-gear-driven vessels. It gives not only the horsepower-hour totals over a given time interval but also instantaneous horsepower readings. Horsepower-hours are an accurate measurement of work expended over a length of time; hence, these readings provide a means for checking the propulsion efficiency of the ship.

The meter has numerous applications: comparing fuel consumption rate with horsepower output under varying conditions; checking performance of propulsion equipment over a wide range of speed; comparing output of power plant for similar trips and distances; studying fluctuations in horsepower output for different sea conditions; checking efficiencies of the power plant; and proving ship performance during trials.

Fig. 42. One of the three heaviest and most powerful heavy cruisers afloat, the USS *Newport News*. The similar USS *Salem* was delivered this year.

The equipment is self-contained and requires no electric power from the ship's supply; it is accurate within ±2 percent of shaft twist at full horsepower rating. Installation is simple, no more than 4½ ft of shaft being used to mount the torsional detector unit and collector rings. There is direct indication of horsepower and horsepower-hours, and operation is continuous.

LAND TRANSPORTATION

DEMAND for electric horsepower in the transportation field continued to boom during 1949, a fact deeply significant in the light of trends in other industries. It meant that electric drive had come into its own on the basis of its ability to earn dollars—the diesel-electric locomotive paying for itself in 5 to 10 years; modern multiple-unit trains and all-electric streetcars offering real economies for mass transportation in metropolitan areas; and trolley coaches boosting revenues and cutting costs in urban transit.

Gas Turbine-electric Locomotive . . . *In U.P. Service*

It was late in 1948 that America saw its first gas-turbine-driven locomotive on the tracks. Extensive testing, including road tests on eastern railroads, was

Fig. 43. This 231-ton electric locomotive for the Chilean State Railways is one of the largest ever exported from Erie

carried out; then in June, 1949, the 4500-hp Alco-GE locomotive was demonstrated to railroad executives and technical men assembled at Erie (Pa.). The locomotive was then shipped to the Union Pacific Railroad for extensive tests in actual service (COVER) under difficult conditions of altitude and temperature. It has since been operating in regular freight service, with Bunker C oil as fuel.

Electric Locomotives . . . *Power-savers*

Ten 3000-volt d-c locomotives were shipped to the Chilean State Railways. Eight are 72-ton road switchers, equipped with four motors and embodying the novel feature of a dynamotor to supply traction-motor power at 1500 volts for switching service. Two are 231-ton locomotives (FIG. 43) for main-line freight and passenger service. They have a 2−C+C−2 wheel

A yard crew looks over the gas turbine-electric locomotive now on the Union Pacific

arrangement, are equipped with regenerative braking, and are rated 4000-hp continuous. Designed for maximum speed of 75 mph, their high tractive-effort rating will enable them to handle trains of 990 tons over 2.2-percent grades at 25 mph.

Diesel-electric Locomotives . . . *95-ton Switcher*

Newest addition to the standard line of diesel-electric switchers for industrial use is a 95-ton unit; the line now ranges from 25 to 95 tons.

Fig. 44. Diesel-electric locomotives of this type found increasing use in light road service and switching

Diesel-electric locomotives for railroad switching and light road service were increasingly popular—twenty-eight 44-ton and forty-six 70-ton units (FIG. 44) were delivered during the year.

The trend to diesel-electric motive power for branch-line operations was noticeably accelerated, particularly

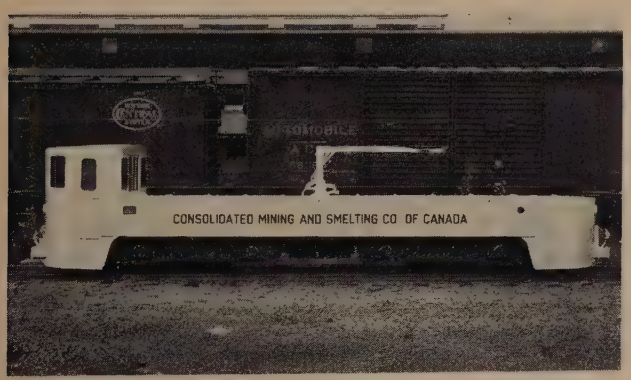


Fig. 45. A high-speed 40-ton mine-haulage locomotive

with the Alco-GE 1500-hp road switcher, which has the same power plant and electric equipment as the 1500-hp road freight locomotive. The mechanical design includes walkways and end steps for switchmen and provision for a train-heating boiler.

Car Unloaders . . . *And Snow Melters*

A Hulett unloader being built by Wellman Engineering Company for the Wheeling and Lake Erie Railroad will be the first with adjustable-voltage control on all main motions, featuring lower installed cost, lower maintenance, and smooth control as contrasted with the conventional constant-voltage system. Turn-around time for the lake boats will be shorter. The unloaders will transfer ore (from the Mesabi range) from lake carriers to open cars for transfer to the steel mills.

One all-electric car dumper was installed as a joint facility of the Baltimore & Ohio and the New York Central at Toledo, and another as a tidewater project of the Chesapeake and Ohio at Newport News (p. 29).

The familiar coiled Calrod heating unit of the electric range, stepped up in capacity and extended to 45 ft in length, is keeping track switches free from snow and ice. In one installation last winter the cost was seven cents per switch per hour of operation. Washington Terminal switches are now being equipped to combat freezing rain.

Diesel-alternator . . . *Voltage Regulated*

The diesel-alternator unit, mounted under the car and supplying power for various loads, has been given a new static-magnetic regulator to control the amplidyne exciter which supplied the field current for the diesel-driven a-c generator. Its high speed of response and high steady-state accuracy prevent wide fluctuation of the voltage during sudden load changes, which would cause objectionable changes in light intensity of fluorescent lamps.

Industrial Haulage . . . *1½-ton Trammer*

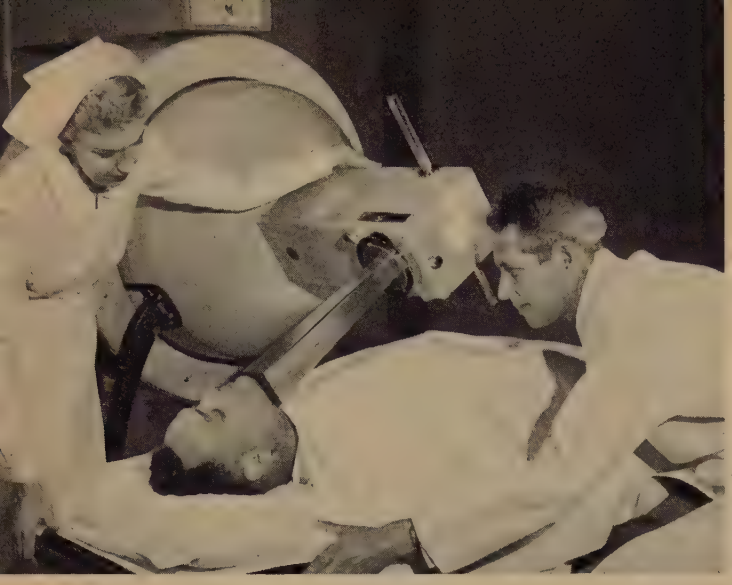
A new battery-powered 1½-ton trammer was developed for small metal-mine operation. A line of high-speed mine-haulage locomotives (FIG. 45) has a rounded-end frame construction which not only gives an improved streamlined appearance but also is important from a safety standpoint.

Urban Transit . . . *Continued Trends*

An increasing trend toward rapid-transit systems continued. In addition to continued operations in New York, Chicago, Philadelphia, and Boston, systems were planned for Toronto, Cleveland, Los Angeles, San Francisco, and Detroit.

A significant fact about many of the year's new installations of trolley coaches was that they were going into service on lines where no overhead facilities previously existed.

Seven cities installed 25,000-kw additional mercury-arc-rectifier substation capacity during the year. The added capacity in general replaced less efficient, obsolete rotating conversion equipment.



A new versatile x-ray therapy machine. Its head is so designed as to permit practically any conceivable combination of rotations, angulations, and height adjustments

ELECTROMEDICAL

• • • • • • • • •

"Building Block" X-ray Equipment . . . *It Grows*

PARTICULARLY outstanding was the design of an x-ray machine based on the building-block principle, to permit the physician's x-ray facilities to grow as his practice grows. The complete unit (FIG. 46) actually consists of 15 subassemblies, which can be added to one another according to the scope of the physician's x-ray work and practice.

There is a basic unit composed of table top, table frame, legs, and Bucky diaphragm (filter for scattered radiation). When used with a mobile or portable type of x-ray tube-transformer assembly, it comprises the simplest unit for radiography, suitable for x-raying less dense portions of the body and for setting fractures and locating foreign objects in the body. As his practice grows, the physician may add a special higher-powered tube and transformer, together with floor rail on which the tube can be moved alongside the table. Hand or motor mechanism may be added later for tilting the table, etc.

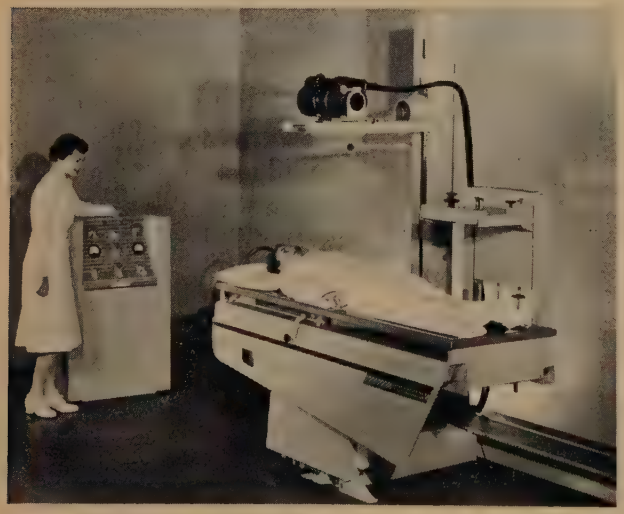


Fig. 46. A "building block" x-ray unit, completely assembled to include all attachments needed in both radiography and fluoroscopy

The same building-block system applies to fluoroscopy (FIG. 47). He may incorporate the fluoroscopic carriage, containing shutters and screen, and later a spot-film device for making radiographs of views as he sees them with the fluoroscope, and subsequently add the tilting device.

Busy radiologists and hospital x-ray departments may add a tube, to have one tube more readily available below the table for fluoroscopy and one above for radiography. The physician, also, can build a complete equipment for both radiography and fluoroscopy.

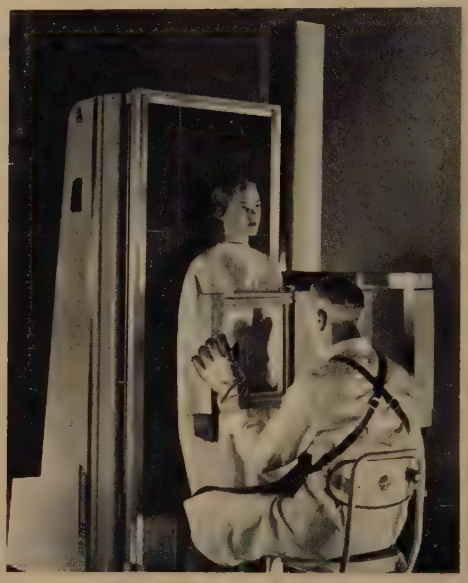


Fig. 47. Using the new building-block x-ray unit for fluoroscopy

The independent floor rail for the tube stand makes it possible, for the first time on equipment of this size, to use a rotating-anode tube for fluoroscopy as well as radiography.

X-ray Therapy . . . *Wide Range*

A wide spectral range of radiation never before available to the therapist was achieved in a new unit designed for all three types of therapy—superficial (skin), medium, and deep—it was also announced by General Electric X-Ray Corporation, Milwaukee. The unit, operating at 100,000 to 250,000 volts, includes a tube with special beryllium window. Beryllium is more transparent than glass to x-rays, which makes it possible to boost the intensity of radiation if desired. The head is so designed as to permit practically any conceivable combination of rotations, angulations, and height adjustments.

The seventh 1,000,000-volt therapy x-ray machine produced by G.E. X-Ray was sold this year to Santa Barbara (Calif.) Cottage Hospital for treatment of deep-seated malignancies. The funds were donated by

Elisha Converse in memory of his wife, who died of cancer.

The standard 250,000-volt equipment for intermediate and deep therapy was entirely revised. The new unit (FIG. 48) is far more compact, has much less superstructure, is more flexible, better safeguarded, and simpler to adapt to special purposes.

X-ray Opaque . . . *Much Improved*

A new diagnostic x-ray opaque substance, known as Veri-O-Pake, remains in suspension indefinitely. The product, a powder, is mixed with water to form a creamy liquid which is swallowed by the patient during fluoroscopy or radiography. It leaves a highly adhesive coating, making it possible to outline the digestive tract for a longer time than did earlier types of opaques. The constipation and nausea frequently associated with some opaques are eliminated; because its high opacity permits use of a thinner mixture, the resulting radiographs have a rare translucency. It is said by physicians

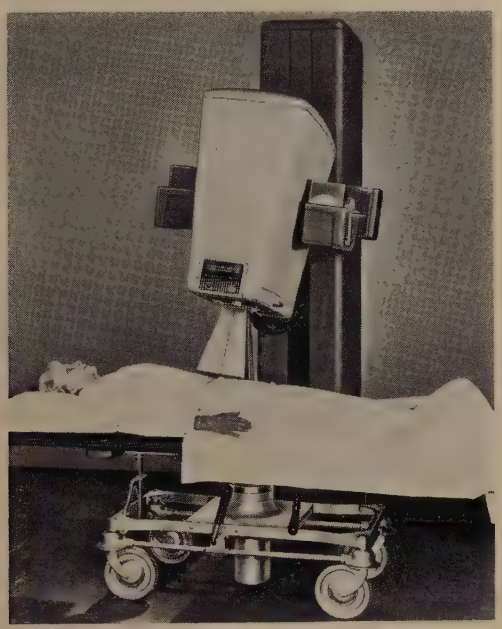


Fig. 48. The new standard 250,000-volt x-ray equipment. Note the streamlined design and absence of floor obstruction in the new unit

to reduce by 25 to 65 percent the waiting period usually associated with making a series of stomach-and-intestine radiographs. A two-to-three-hour wait is in most cases ample.

Film Drier . . . *Far Faster*

A new type of x-ray film drier exceeds the output of other film driers by as much as 100 percent at low humidities and 200 percent at high humidities. Although it holds only 15 films at a time, it dries them so much faster that it will put out more films a day than an 18- or 24-film drier. The drier can be provided with doors both front and back, and thus installed in the wall of a darkroom to provide convenient access from either side.

Leader in the low-priced television receiver line was the nation's first plastic television cabinet

ELECTRONICS

TRANSMITTERS

Television . . . *Highest Tower So Far*

DURING 1949 more than fifteen television transmitters of 5-kw output were installed. These included one at Milan, Italy, operating on standards compatible with their power systems, and one at Rio de Janeiro, Brazil. These installations include, in addition to the transmitter, antenna installations, control console, and varying amounts of studio and control equipment. One of the outstanding stations is WOR-TV, with a 750-ft tower, the highest television tower in America today.

The highest-gain television antenna in existence, completed during the latter part of the year, incorporates 12 bays with a power gain of over 13, on television channel 9. There is also a unique diplexer for this frequency which permits the use of a single 6⅛-in. transmission line for carrying both the aural and visual signals up the tower to the radiating structure.

In the studio, an electronic viewfinder (FIG. 49) was added to the existing studio camera to accommodate lower lighting levels and increased sensitivity in the image orthicon tube. New monitors feature a more

compact design at a lower cost and with improved characteristics. Co-ordinated with these monitors is a complete line of block-built master- and studio-control equipment designed for any size of station.

Fig. 49. The electronic viewfinder accommodates the lower light levels and increases sensitivity in the image orthicon tube of television cameras

Broadcast . . . *50-kw Amplifier*

The line of studio broadcast equipment was rounded out by the introduction of a new portable amplifier which incorporates advanced design features. In addition, a limiting amplifier proved very successful in increasing the modulation capabilities, and hence the coverage, of AM stations.

In the FM and AM broadcast fields a large number of installations, including powers ratings up to 50-kw, were furnished. A special 50-kw FM amplifier was built and tested, representing the highest authorized transmitter power for this service in America.

Marine . . . *Bi-focal Radar*

A new marine FM radiotelephone was produced, primarily for use by the Great Lakes ore fleet. The 156-megacycle equipment can communicate on any one of eight quickly chosen frequency channels, and will do much to relieve the present jamming of AM bands. Applications are being found on other vessels.

During 1949 production started on a new marine radar, the "bi-focal" electronic navigator (FIG. 50), which permits the skipper to study both near and far objects simultaneously. This is done by the use of two cathode-ray scopes, one held at a constant range of two miles, and the other variable from ½ to 40 miles. In this manner the captain is constantly warned of objects within a 2-mile radius of his ship, no matter which range he may choose on the variable scope.

Aircraft . . . *Surveillance*

In the improvement of electronic facilities for the control of aircraft, the major production effort is being carried out for the Civil Aeronautics Administration. It involves the design and manufacture of a large quantity of airport-surveillance radar systems. These devices, when installed at airports, will give traffic controllers a complete picture of all airplanes within thirty miles, regardless of weather conditions. The equipment incorporates: moving-target indication, which allows the operator to eliminate all objectionable radar reflections due to stationary targets or severe rainstorms; complete standby operation; and remoting system, which allows the radar set to be located as far as two miles from the control tower.

RECEIVERS

Radio . . . *New Portables*

FOUR portable radios were introduced, three of them weighing less than nine pounds each. Three of them can be operated from batteries or either a-c or d-c power lines, the fourth on batteries only. Six deluxe table radios were also added to the line during 1949.

Fig. 50. Objects both near and far can be studied simultaneously by means of the "bi-focal" electronic navigator

All models are a-c/d-c receivers. A table radio featuring FM as well as the standard AM band (both antennas built-in) topped off radio receiver developments.

Television . . . *"Black Daylight"*

A wide variety of television receivers was introduced in various price brackets during the year, featuring both "daylight" and conventional picture tubes in 10-, 12½-, or 16-in. sizes. These were for table, console, and combination units.

Highlighted was a line of low-priced receivers made possible by a simplified circuit design.

New circuits provide automatic sound, enabling the user to tune for the best picture, eliminate "drift" of sound, minimize electrical disturbances. Built-in antennas for high-signal areas were also introduced.

A new "black-daylight" tube was used in some TV sets to improve picture contrast and clarity without sacrificing brightness. The tube uses a neutral-density glass for the face plate and retains the "daylight" feature by aluminizing the interior of the tube and thereby producing 80 percent more brightness than in conventional tubes.

Record Changer . . . *3-speed Automatic*

A dual stylus (FIG. 51) was added to the electronic reproducer for playing microgroove and standard records merely by depressing and turning a button on the top of the tone arm. Stylus pressure was reduced to ¼ ounce, for longer record wear and stylus life. Through the use of three spindles, no separate adjustments are necessary to set the tone arm down automatically for the correct record size. Starting or setting of the tone arm for correct record size is accomplished automatically when the desired spindle is inserted at the center of the turntable.

SPECIALTIES AND INSTRUMENTS

THE Play-Talk, the first magnetic recorder-playback machine designed for the child's playroom, is the latest addition to the toy line (FIG. 52). A speaker is used both as microphone and loudspeaker. By talking into it, the child can record for two minutes on a rotating magnetic disk; with a flip of the switch he listens to the message on the playback. The same disk can be used again and again for different messages.

Another magnetic recorder—the electronic narrator—has been developed which will repeat a message or series of messages any number of times, without being rewound or reset; a continuous loop of magnetic tape permits approximately two minutes of recording or playback time. Each recording can be started automatically by any such means as breaking a light beam, stepping on a mat, or flipping a switch.

With the rising demand for dependable equipment to align television sets, a complete set of precision instruments was developed. Included are: a marker generator which utilizes a quartz crystal to supply video, audio, and adjacent-channel audio frequencies simultaneously and accurately to within two parts in 10,000; a sweep generator which has borrowed the old concept of saturable reactors from the low-frequency field and applied it to high-frequency techniques for producing an exceptionally wide, constant-amplitude sweep; and a 5-in. cathode-ray oscilloscope whose features are unusually bright trace, high sensitivity, wide frequency response, and a plurality of built-in calibrating voltages.

Fig. 51. Showing with the aid of a mirror how the dual stylus can be turned for standard or microgroove record playing

Fig. 52. The Play-Talk, magnetic recorder-playback machine, is the latest toy. A speaker is used as both microphone and loud-speaker

An electron tube is tested in thirty seconds, instead of the previous four minutes, with this new testing device

ELECTRON TUBES

Television . . . *Germanium for UHF*

THE active development of cathode-ray tubes for television use continued through the year. Metal-envelope tubes were introduced, and the requirements are being met by 8½,- 12-, and 16-in. sizes. Use of the aluminumized screen continued and has been supplemented by a dark faceplate that reduces halation and the effects of ambient light, greatly improving the picture contrast. The combination of the metallized screen and the glass filter affords these advantages without sacrifice of light output.

Germanium diodes have evolved from a highly specialized device into a standard component being manufactured with high-speed manufacturing techniques, and are being used in many types of television receivers. A new UHF germanium diode has recently been announced which carried the use of germanium diodes from the RF into the UHF field. This new diode will operate at frequencies between 100 and 1000 mc; typical sensitivity is 4 to 8 microvolts, with noise index of 2.5 to 5 microvolts and peak inverse of 5 volts. This unit represents an important step in securing a UHF diode sturdy enough for widespread commercial use.

Radio . . . *Gated Beam*

The introduction of a receiving tube in which an electron beam is focused upon a grid through a narrow slot in a positive accelerator marked a radical departure from conventional design. Called a gated-beam tube, it represents the first large-scale commercial application of this form of cathode gun to receiving tubes. In addition to use in FM and television-limiter circuits to reduce the set component cost, it opens up an entirely new field of design possibilities.

Industrial . . . *Power Rectifier*

Progress was marked in the power-rectifier field by the introduction and successful operation of the pumpless ignitron tank (FIG. 53). Smaller sealed units which require continuous pumping have been used for many years. This larger unit, once it has been exhausted, operates without the complication of continuous pumping and can be opened and repaired on the premises.

Another advance in the power-rectifier field was a reduction in size and cost of firing circuits, closing the gap between thyratron and ignitron types.

New water jackets, completely new in concept and design, were developed for vacuum tubes used in electronic heaters. Cooling water itself forces a sealing neoprene "O" ring always tighter; even bursting pressures involve no leakage. An easily applied metal split ring, with large threads, exerts the start-off sealing effect, locking tube and "O" ring in place. After that the pressure of the circulating water takes over, producing an ever-more-effective seal.

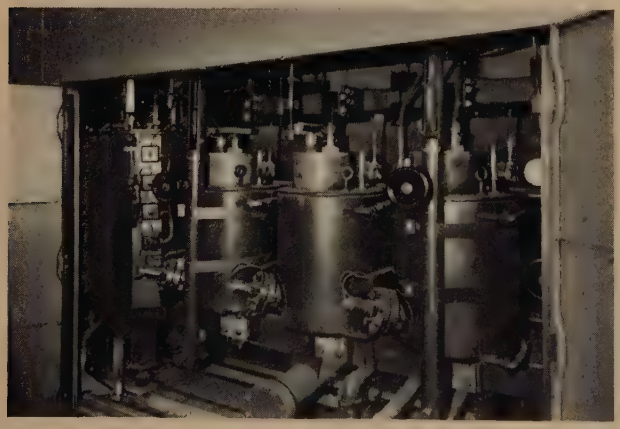


Fig. 53. The pumpless ignitron tank operates without continuous pumping and can be opened for repair on the premises

Three new types of street-lighting luminaires which use fluorescent lamps, providing softly diffused light for night driving

LIGHTING

TRENDS in general-lighting practice are difficult to appraise, but developments through the year seemed to emphasize a growing acceptance of continuous-row installations using fixtures equipped with 8-ft instant-starting slimline lamps; a greater desire to design lighting systems for minimum glare; and a growing awareness of fluorescent-lamp colors and their application. Improvements in filament, fluorescent, and mercury lamps continued to give greater value and to increase the illumination levels economically justified.

Fluorescent Lamps . . . *Four and Six Feet*

New fluorescent lamps that bring out the "full beauty" of all colors and are complimentary to complexions were made possible by the development of special fluorescent powder designated as DR phosphor. Called "de luxe cool white" and "de luxe warm white," the new lamps will be preferred for the most part in living areas, where it is important that colors and complexions appear at their best but highest-efficiency lighting is not vital. The "4500 white" lamp becomes the "standard cool white," and the "warm tint" becomes the "standard warm white"; these lamps will be most effective in working areas—where the need is for high-efficiency lighting with reasonable color rendition.

Two new slimline fluorescent lamps, 1½ in. in diameter and 4 and 6 ft long, were produced as companions to the 8-ft lamps of the same diameter. They are for instant-start operation, have single-pin base construction, and use standard "push-pull" slimline lampholders. Colors are white, 4500 white, and warm white.

Several commercial airlines adopted fluorescent lighting for new transport planes; the previous obstacle of

weight was overcome by use of capacitor ballasts. The Boeing Stratocruiser uses 30 fluorescent lamps, of which 19 are operated on capacitor ballasts with a weight-saving of 21 lb compared to conventional choke-type ballasts. A new circuit for the high-frequency operation of fluorescent lamps also improved the standard of lighting in buses.

Some of the New York Subway System stations in Brooklyn now have ten times as much light as do those having the usual single footcandle of pin-pointed illumination provided by bare incandescent lamps. A minimum of 10 footcandles of evenly distributed light (FIG. 54) results from the installation of 1319 new glass-enclosed fluorescent fixtures. Every ninth lamp in the long, continuous fixtures, and other lamps at key points, operates on direct current to provide emergency light in case of power failure on the regular system.

An instant-start ballast for the 32-watt circline and other lamps was developed in ratings suitable for home applications. Called the "Trigger-start," this ballast actually permits almost instantaneous preheating of the lamp cathodes by use of auxiliary windings in which the voltages electrically cancel each other when the lamp begins operation. Light output from lamps is not impaired, and 80 percent of normal lamp life on switch-start operation is obtained.

Single-lamp ballasts in three important ratings were basically redesigned. The new standardized 30-, 32-, and 40-watt design provides improvement in noise, quality, and an average of 20 percent reduction in price. Utilizing a slightly larger cross section, the new units employ a new core design which reduces material, permits more positive clamping of core laminations, and reduces assembly time.

Incandescent Lamps . . . *Improved 75-watter*

Reduction in size of the 75-watt general-lighting incandescent lamp, together with an increase in light output and efficiency, was made possible by use of the "coiled-coil" filament. Its size and shape, same as the present 60-watt lamp, make it suitable for use in portable lamps and fixtures.

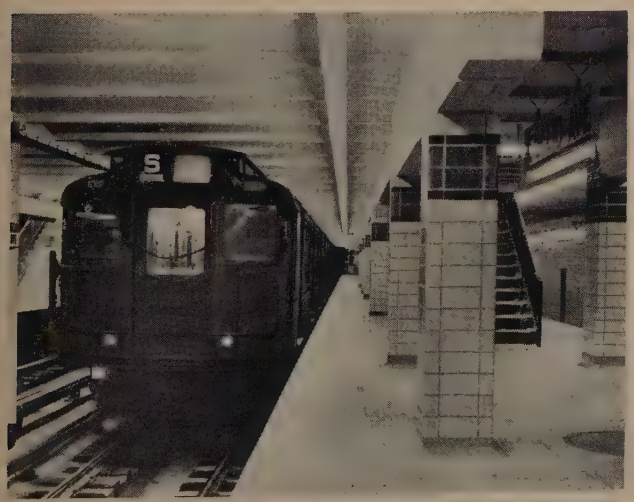


Fig. 54. Six-foot fluorescent lamps provide plenty of illumination in New York City's Euclid Avenue subway station

The enameled yellow lamp, previously in 25-, 60-, and 100-watt sizes, was produced in a 150-watt size for outdoor lighting, for minimizing bugs at parties. It does not repel insects; it simply is less attractive to them than white light.

Special-purpose Lamps . . . *Bikes, Photos, Germs*

A new bicycle headlamp (FIG. 55), a small edition of the one-piece all-glass sealed-beam automobile headlamp, produces a beam pattern about 5 ft wide

Fig. 55. A new bicycle lamp—small edition of the sealed-beam automobile headlamp

and 30 ft long. Rated 5 volts and ½ amp, it has a screw-terminal base, and has a designed life of 100 hours; it can be operated satisfactorily from a battery of the 5-volt hand-lantern type or from a bicycle generator.

An automobile trouble light developed by Monowatt Incorporated takes current from any type of dashboard cigarette lighter; the spring-wire side contact of the plug acts as a cam and holds tightly in any type of lighter receptacle. With 12 ft of rubber-insulated wire, the light reaches any part of the car.

Intended primarily for spotlighting stages, television on-the-spot shows, or other areas at distances of 75 to 150 ft, is a 3000-watt incandescent lamp producing an estimated 900,000 candlepower. The lamp (FIG. 56) is four inches in diameter and nearly a foot long. Of bipost construction, it is intended to be used vertically, base up. Its rated life is 100 hours, and it can be used with standard voltages on either a-c or d-c circuits.

A new high-speed photographic lamp will produce about 75,000 footcandles—fifteen times the value of sunlight. The lamp has a reflector-type bulb of 5-in. diameter and is rated at 750 watts. It has been successfully used for making movies both in color and in black and white at the rate of 8000 pictures per second. The design life is six hours.

Fig. 56. This 900,000-candlepower lamp is expected to rival arc lights in many stage-lighting applications

Fig. 57. Narrow-beam 375-watt photoflood lamps for home movie makers

For home movie making there was produced a 375-watt photoflood lamp for both color and black-and-white pictures (FIG. 57) which, because of its narrower beam spread, puts even more light on a subject than does the wide-beam 500-watt reflector photoflood lamp. The lower wattage permits use of four lamps simultaneously without exceeding the capacity of most household electric circuits. Color temperature is 3400 Kelvin; service life, four hours.

A tiny neon glow lamp, consuming only a penny's worth of electricity in a whole year, is mounted in the top of a switch plate (FIG. 58) made by Associated Projects Company of Columbus (Ohio). It glows when the room lights are off and goes off when they are turned on.

It was announced during the year that the American Medical Association's Council on Physical Medicine had accepted G-E germicidal lamps for the disinfection of air in hospitals, nurseries, and operating rooms.

Two additions were made to the line of infrared lamps for industrial processing: a 500-watt globe-shaped lamp, representing an increase of 125 watts over the previously most powerful lamp of its type, and a 375-watt with a heat-resistant bulb and self-contained reflector. Chief advantage of the 500-watt lamp is its ability to increase infrared-energy concentration and to hasten the processing of certain materials.

Street Lighting . . . *Fluorescent*

An integral assembly of the transformer, controller, protector, primary and secondary lightning arresters, and fuse cutouts has been achieved in a new substation

Fig. 58. There's no groping in the dark to find this switch; a tiny neon light is on when the room lights are off

constant-current regulator for street lighting. The various units are interwired at the factory; all components are readily accessible.

The first installation of the world's largest street lights was dedicated during the year in Akron (Ohio). The luminaires are 25,000-lumen giants, 21 in. in diameter and nearly a yard high. Approximately 180 units are located along the city's Main Street.

The world's first major installation of street lights individually self-controlled by photoelectric cells was completed at New Milford (Conn.). The 190 luminaires, along seven miles of roads and streets, turn themselves on and off singly and automatically as conditions of visibility demand.

Probably the country's brightest street, with a 5-footcandle average. Court Street in Kankakee (Ill.) is illuminated by 21,000-lumen mercury-vapor lamps spaced 65 ft opposite

Occupying less than 4½ sq ft of floor space, the 2-ton-capacity "packaged" air conditioner provides economical cooling where space is limited

AIR CONDITIONING

• • • • • • • • •

Heat Pump . . . *Year-round Comfort*

THE progress of the heat pump is indicated by the number of field-fabricated installations in residences and commercial establishments.

Eight pilot installations of package heat pumps were made, with the co-operation of utility companies, in selected areas throughout the country. These are completely automatic and use air as a primary heat source, some installations using water or ground coil as a supplementary source. Two 3-hp compressors are employed in each unit, some operated on 3-phase power supply and others on single phase. Each is completely instrumented; an automatic camera records all readings periodically and on signal from changes in pump operation, permitting detailed analysis of performance.

Providing both cooling and heating via refrigeration seems practical for many commercial and industrial applications. But before any safe prediction can be made as to widespread residential use of the heat pump, further study must be made of such vital factors as relative cost, extent of demand for year-round air-conditioning, availability and cost of necessary power, and development of heat-storage devices to supplement the pump at peak demand.

Refrigeration Machinery . . . *Condensing Units*

Standardization and product improvement were features in the refrigeration field. A 2-hp water-cooled condensing unit was introduced, notable for higher speed and smaller, more compact design.

Developments in the 10- to 60-hp range of water-cooled condensing units included built-in unloaded starting as standard equipment and, in the 40- to 60-hp range, capacity modulation was offered as an optional feature.

Automatic Heating . . . *Air-Wall Heating*

To meet the demand for automatic heating equipment for low- and medium-priced homes, the Air-Wall heating system was introduced. This forced warm-air system, using a standard gas- or oil-fired furnace, offers improved heating and substantial savings in installation cost through the use of furnished prefabricated ducts (FIG. 59). Compact and inconspicuous registers direct warm air over cold walls, furnishing regular warm-air heat and at the same time warming the walls so that they provide a radiant-heat effect.

A compact oil-fired boiler for radiant-panel heating was introduced. With piping concealed by a white-enamel jacket (FIG. 60), the unit is designed for kitchen or utility-room installation in small homes. It is equipped with a built-in expansion tank, tankless-type water-heating coil, and a fast-acting "capillary action" control which responds quickly to drops in water temperature.

Refinements of the standard oil-fired boiler include location of a control panel on the front of the boiler for ease of servicing, and provision for a built-in tankless or tank-type domestic hot-water coil. In the steam-boiler unit, an improved low-water cutoff has been incorporated.

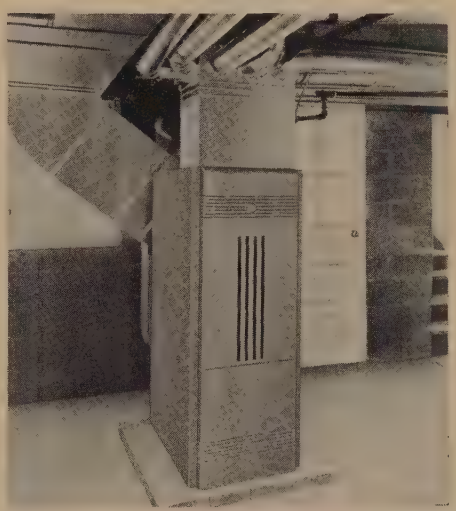


Fig. 59. The small, prefabricated round ducts of the Air-Wall heating system are quickly assembled and installed

Fig. 60. The new white-jacketed oil-fired boiler for radiant-panel heating is also adaptable to ceiling-panel, baseboard-radiation, and other forced hot-water systems

This portable dishwasher does the same dishwashing job as the fully automatic model, is 36 by 23½ in., and is easily rolled out of the way.

APPLIANCES

Dishwasher . . . *No Permanent Fixtures*

IN 1949 a number of lower-cost appliances were developed. One example was the portable dishwasher which does the same dishwashing job as the fully automatic model but, because it does not require permanent plumbing or electrical connections, saves the purchaser about $50 in installation costs. To connect the dishwasher, the rubber inlet hose is attached to the hot-water faucet and the electric cord is plugged in. Washing is done by a stream of hot detergent solution sprayed on all surfaces by a high-speed impeller.

Three new automatic dishwashers which permit more flexible installation were announced. They are equipped with a small centrifugal pump which discharges the dishwasher through a drain hose and sink spout into the sink bowl or other existing drainage facilities. The pump allows the appliance to be installed anywhere in the kitchen without direct connection to the drain line.

Refrigeration . . . *Combination Units*

To bring the convenience of the combination refrigerator-home freezer to more people, two low-priced appliances were developed. One is a 10-cu ft unit, incorporating a 2-cu ft freezing compartment and an 8-cu ft refrigerating compartment that needs no defrosting. The other is an 8-cu ft unit, with 1½ cu ft of freezing space and 6.7 cu ft for standard refrigeration. Both have two doors and two refrigerating systems.

A new 11-cu ft home freezer which holds 389 lb has three removable wire baskets to facilitate food handling, an alarm system as a protection against food spoilage, and a handy storage compartment for wrapping materials and other supplies. In spite of its much greater capacity, the new unit is the same width and height as the 8-cu ft unit, and only a foot longer.

Kitchen . . . *Complete in 60 Inches*

There is now a complete electric kitchen that fits into a space only 60 in. wide, yet has complete cooking, refrigeration, storage, and clean-up facilities. Designed primarily for use in small homes and apartments, the kitchen (FIG. 61) includes a range with three cooking units, a 4-cu ft refrigerator, a 39-in. stainless-steel sink with space in the cabinet beneath for a Disposall kitchen-waste unit, and two wall-storage cabinets.

A new, smaller Disposall kitchen-waste unit was designed especially for homes where existing plumbing complicates installation of the standard unit. By use of a recently developed plumbing trap, the new type can be quickly and conveniently installed in old or new sinks if the distance between the center line of the wall drain and the bottom of the sink is at least 7 in.

Clothes Washers . . . *Flexibility of Operation*

Hotpoint Inc. developed an automatic clothes washer featuring thorough and economical agitator washing, spray and overflow rinsing, and centrifugal water extraction. The appliance is flexible in both installation and operation. The fluid-drive component of the power train eliminates harmful vibration, and semi-automatic operation, when cold water is avilable for plumbing to the machine, permits its installation on wood floors above other living units and even on back porches. The user has freedom of choice in water volume, temperature, and washing aids, and in skipping or repeating any phase of the washing cycle.

Fig. 61. For limited space, the 60-in. electric kitchen offers complete cooking, refrigeration, storage, and clean-up facilities at the homemaker's finger tips

A new all-automatic washer from Bridgeport washes a full load of 9 lb of clothes in 17 gal. of water, or up to 5 lb in 10 gal. Water extraction is improved by retaining rings inside the wash basket. A six-gallon overflow rinse has been added to float accumulated soap and curd off the top of the water.

Portable Mixer . . . *Grill-Waffle*

A redesigned portable electric mixer (FIG. 62) weighs only 3½ lb without the base and occupies considerably less space than previous models. The motor is horizontal, to give the appliance new, low lines and to permit storage of the entire mixer in a small space. Three beaters provide triple-whip action for a wide variety of kitchen tasks. With one quick twist, the mixer can be inverted for use with the juice extractor.

More cooking area was built into a new combination sandwich grill-waffle iron; it bakes two plate-size waffles at one time. As a sandwich grill, with the top folded back, it provides almost a square foot of frying surface (FIG. 63). The aluminum sandwich and waffle grids are quickly interchangeable.

Clocks . . . *And Timers*

A new bell alarm-clock movement, developed and put into production by Telechron Inc., incorporates the combined features of improved bell tone—accomplished by developing a new vibrator—and reduced cost—by using standard parts common to other quantity-production alarm movements.

A Telechron radio timer movement incorporating the Sleep Switch permits an individual to drop off to sleep to soothing music that plays as long as desired, up to an hour, before turning the radio off automatically. The radio automatically comes on the next morning in accordance with the preset time.

A new Telechron defrost timer movement, when put in series with a refrigerator motor circuit, permits the homemaker to set the length of time the refrigerator will defrost during the night, starting at midnight and extending any period as required by weather and refrigeration uses, up to seven hours.

Among many new clocks at Bridgeport were: a 4-in-square alarm; a kitchen clock in a molded plastic case with a tailored built-in appearance; and a mantel clock with full Westminster chimes.

Ranges . . . *Extra-high-speed*

A new feature of the two de luxe ranges, the Stratoliner and Liberator, was an extra-high-speed Calrod utility-size surface cooking unit, rated 1600 watts, that is 20 percent faster than other units on the market today.

Vacuum Cleaners . . . *Faster*

To fill the needs of hotels, clubs, etc., where frequent, thorough, and fast cleaning is desirable, an industrial vacuum cleaner weighing 23½ lb—5 lb more than some domestic cleaners—was built for both wet and dry pickup.

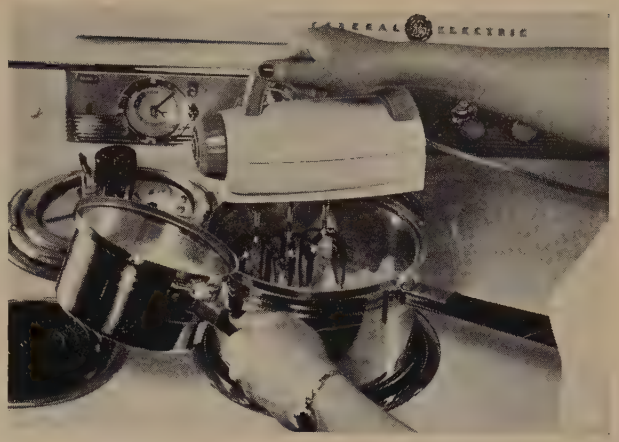


Fig. 62. Light weight and triple-whip action make the portable mixer the answer to countless kitchen tasks. A quick twist inverts it for use with the juice extractor

Fig. 63. Easy removal of waffle grids quickly converts this handy appliance into a sandwich grill. More cooking area is thus afforded

A new streamlined tank-type vacuum cleaner was produced with greater suction power and self-locking attachments. In spite of its extra power, the motor is exceptionally quiet, since it is suspended in rubber. Lightweight attachments and hose and extension tubes automatically lock together when assembled. They are unlocked by a push button.

Heaters . . . *Rotating Reflector*

An unusual heater, with a rotating reflector, throws both radiant and fan-forced heat throughout the room. The highly polished aluminum fan blade, which takes the place of the usual nonreflecting small fan, revolves at low speed to produce maximum air movement with the greatest throw of heat. Because the heater is suspended between U-shaped arms rising from a circular steel base, heat can be directed at any angle from horizontal up.

A new, low-temperature, electric radiant-heating system consists of panels for use either in complete house heating or for occasional booster heating. The panel is a laminated sheet consisting of a Textolite core, in which fine resistance wires are embedded, and outer layers of aluminum foil. The panel is very light in weight, and easy and inexpensive to install. It gives quick response to changes in room temperatures and thus maintains uniform warmth to a much greater degree than conventional systems.

The Flex-A-Power busway system—an overhead electric power highway

CONSTRUCTION MATERIALS

Remote Control . . . *Utility Unit*

A SELF-CONTAINED remote-control utility unit was designed for both indoor and outdoor lighting, sound, and heating equipment. Approved by the Underwriters' Laboratories, Inc., the unit is protected by a die-cast aluminum housing and a snap-on weather-resistant cover of stamped aluminum. Its upper compartment is for low-voltage wiring and the lower is for the 125-volt connections as required by the NEC. The lower unit has two threaded openings for ½-in. pipe, or insulated bushings for use with open wire. (There is a screen drain in the bottom for proper condensation.) The relay is rated ⅓ hp, 15 amp, 125 volts a-c; or 5 amp, 250 volts a-c.

Switches . . . *Remote-control Wiring*

A new switch for remote-control wiring systems (FIG. 64) is a flush-mounted plastic switch of normally open single-pole double-throw momentary-contact type; one or more can be connected in parallel. Another (FIG. 65) is a combination master selector and control switch. The user may operate separately any one of nine circuits or, with one sweep, turn them all on or off.

By means of one push button a new, compact switch for the electric-range industry will give directly any desired heat. It is not necessary to go through unwanted positions, causing unnecessary making and breaking of contacts, to arrive at a wanted position; result will be longer switch life and less radio interference. Included are an eight-position 7-heat switch (FIG. 66) and a six-position, 5-heat switch for surface units, both rated 15 amp, 125/250 volts a-c; there is also available a four- or five-position circuit-selector switch for three double-pole and one single-pole circuit.

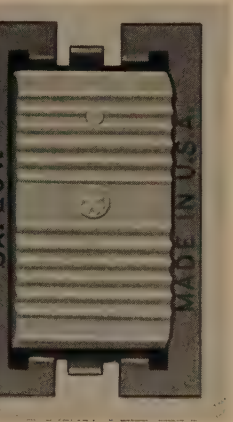


Fig. 64. Flush-mounted plastic switch for remote-control wiring systems

Fig. 65. Master selector switch for remote-control wiring system

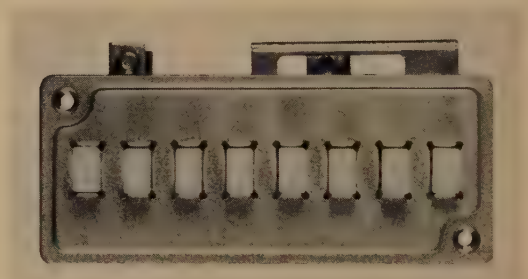


Fig. 66. There are decided advantages in this push-button switch for electric ranges. Any desired heat is obtained directly by pushing one button.

The Trumbull Electric Manufacturing Company of Plainville (Conn.) developed a front-operated switch of unusually high interrupting capacity for modern high-capacity distribution systems, available in 30-, 60-, and 100-amp sizes. Pole units are self-contained switches, front fusing for compactness and with a magnetic arc-quenching action—the first of its kind ever marketed in a switch—similar to the arc-interrupting principle of modern circuit breakers.

Flex-A-Power . . . *Trolley Busway*

Trumbull's Flex-A-Power busway system, which will take power from the outside transformer, carry it through the main breakers, and deliver it to individual loads, was extended to include a new kind of plug-in or trolley busway for modern lighting systems, small power tools, and business machines. Rated 50 amp, 250 volts, it makes two, three, or four circuits available in one compact housing and allows independent control of each.

The steel housing which encloses the copper bus bars may spread out overhead like a whole network of highways to carry power over the full length and breadth of the plant or building. Unlike conventional wiring systems, which require fixed outlets at selected spots, this system may be tapped by an insert plug or a trolley at any point along the run.

Panelboards . . . *Six-circuit Sections*

Two new lighting panelboards were introduced by Trumbull: the NTPR, designed for economical group and branch-circuit control of lighting distribution for industrial and commercial applications; and the NTPS, for smaller installations. Both types are built up in six-circuit sections, with sturdy quick-make, quick-break tumbler switches, positive-pressure contacts, and compact construction.

Quick Clamp . . . *Reduces Wiring Time*

A one-piece plastic cap and a one-piece plastic connector (FIG. 67), developed by Monowatt Incorporated, provides a simple and safe way to attach a cap to an appliance cord: (1) cut the end of the cord square, making certain the copper wires do not protrude, (2) slit cord slightly between wires, (3) insert cord in opening in side of cap, (4) press down clamp on top, and the cap is ready to be plugged into the outlet.

Still other new Monowatt developments were a candlelabra socket with a special contact spring (its varied uses include lighting the push buttons on a kitchen range); single and double white porcelain-like Plaskon receptacles which fit in the splashboard of a kitchen range; and a television-receiver cord set with brass pressurized wiping contacts to prevent any distortion due to loose connections.

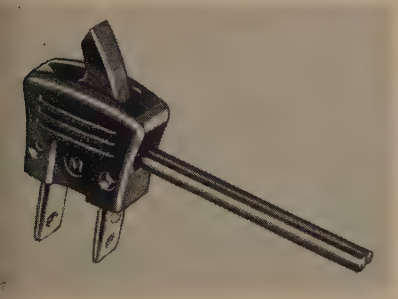
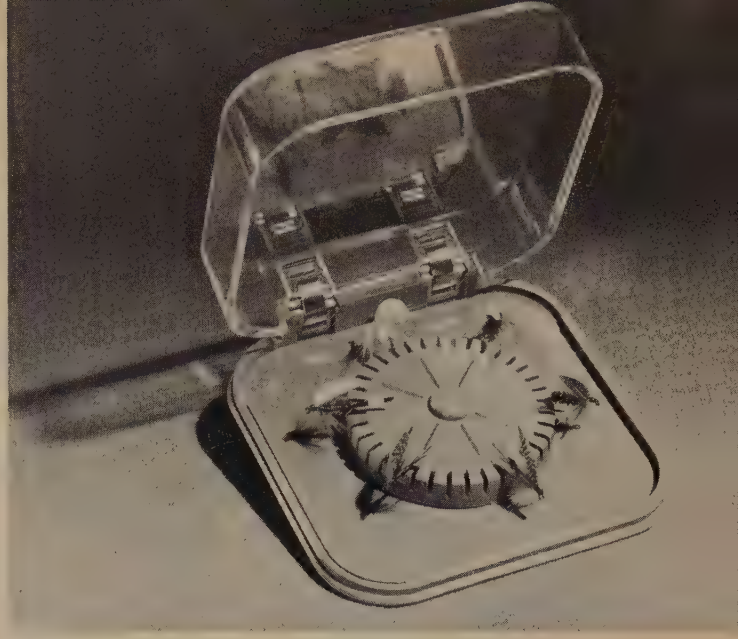


Fig. 67. Quick-clamp cap cuts wiring time to seconds. Clamp at the top is pushed down and the cap is ready to be plugged into an outlet

Heater Cord . . . *And Nonmetallic Sheathed Cable*

Preen-X is a new, braidless heater cord that is both nonfraying and nonkinking. Its insulation jacket is of Neoprene, and hence is resistant to oil, high heat, and moisture. Easily cleaned, and defying discoloration and staining, it is easy to rip, to strip, and to connect to small appliances.

In an improved BraidX nonmetallic sheathed cable, construction is simplified by eliminating the braid over the single conductors and applying the paper armor directly over the rubber insulation. Flame- and moisture-retardant, with paper armor color-coded to facilitate installation, this cable is so designed that the wire can be stripped in one quick, clean operation.



For the fisherman, a fly-box in which an alnico permanent magnet holds flies securely and carefully. The transparent plastics case stays closed or opened, as desired

CHEMICAL AND METALLURGICAL

METALLURGICAL PRODUCTS

Cemented Carbides . . . *In Many Fields*

CARBOLOY cemented carbides recorded advances during the year in several major fields of operation. In the metalworking field there was an improved Grade 905, particularly useful in machining cast iron of high tensile strength as well as other alloys and nonferrous metals. New heading hammers, with markings, were developed for manufacturers of bolts, screws, and rivets. There were also new carbide applications in steel-metal die and automatic screw-machine operations.

An improved heavy-duty carbide-tipped bit was designed for use on all coal-cutting machines using ½-by 1-in. bits. The tip of the shank at the cutting end is flush with the tip, permitting unimpeded flow of coal, minimizing "bug dust." Shanks of forged alloy heat-treated steel give maximum resistance to bending, yet are soft enough to permit the setscrew to dig in.

Rock drills in diameters up to 9 inches now employ cemented-carbide inserts. Formerly the 6-in. diameter was the maximum available.

Carbide tools are enjoying a wider application in the field of stone cutting, which includes quarrying and fabricating various types for monuments and structural stone. In some cases such tools have outlasted steel tools as much as 40 to 1.

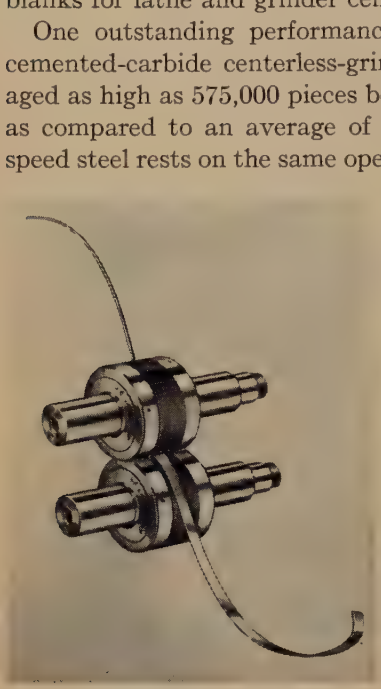
Progress in woodworking applications of carbide tools continued strong through the year. A cabinet manufacturer who had been using such tools built a new plant, of 30,000-sq ft floor area, to be devoted exclusively to the manufacture of carbide tools and tool grinders

U OF I
LIBRARY

for the woodworking industry. The Carboloy Company supplies cemented-carbide tips and other items.

As components of machines, machine tools, and fixtures in wear-resistant applications, there were developments in solid cylinders, special shapes, and improved blanks for lathe and grinder centers.

One outstanding performance record was that for cemented-carbide centerless-grinder rests, which averaged as high as 575,000 pieces between reconditionings, as compared to an average of 1600 pieces with high-speed steel rests on the same operation. In another case,



Flat-wire rolls, developed for rolling small-size wire of high- and low-carbon steel

steel feed pawls on internal grinders had to be replaced after four or five days; carbide feed pawls are still running after three years of continuous operation.

Magnets . . . *Two New Alnicos*

Alnico 5 DG, a modification of alnico 5, has the crystal structure aligned in the direction of magnetization. Smaller magnets may be used in loudspeakers and other communications equipment. This in turn makes possible a reduction in size of the speaker frame and a lower equipment weight. The magnet will provide the highest external energy and residual induction of any permanent-magnet material now known.

Alnico 7, with a higher coercive force than any other grade of alnico, was developed specifically for applications where a high demagnetization force is present, as in motors, generators, and variable air-gap devices.

SILICONES

A NEW silicone insulating resin enabling electric equipment to operate at temperatures as high as 356F is finding application in impregnating spun glass and asbestos wire coverings and for binding coils, windings, and other motor parts; it has excellent dielectric strength as well as superior heat and water resistance. The resin dries tack-free in less than 30 minutes at relatively low temperature, and can be cured to a tough, flexible film.

Only one part of a thin, colorless silicone liquid in 10,000 parts of certain coating materials need be used to eliminate the separation of pigments and give a more uniform painted surface. Paint manufacturers have long sought a means for correcting pigment separation in oil and synthetic based paints and lacquers. This fault caused painted equipment to reveal two or more color tones. The new liquid is most effective when mixed with paint ingredients at the time of manufacture, and is recommended to paint manufacturers only.

A silicone oil that simultaneously cleans, sterilizes, and lubricates dental handpieces is relatively non-volatile and does not vaporize at the temperature required for sterilization. When used in dental offices, the fumes often emitted by conventional sterilizing oils is eliminated.

An invisible coating of Dri-Film water repellent has reduced a full day's dishwashing chore to a few minutes of rinsing at the U. S. Rubber Company's laboratories. Chemists there said the silicone water repellent prevents adherence of sticky latex to hundreds of small glass dishes in which samples are analyzed for quality.

RESINS AND PLASTICS

A LIQUID resin was developed to permit foundries to salvage castings which otherwise would be rejected because of porosity, and to permit their use on applications involving oil or vapor pressures. The polyester-type resin converts to a tough, clear solid, free of voids, through the action of catalysts and heat. Castings are sealed by vacuum impregnation and a subsequent short oven bake.

A new coating resin designated as R-108 adheres to metals, glass, wood, and plastics; is tough, flexible, and resistant to abrasion; and is resistant to corrosive chemicals over a wide temperature range. It is unusually resistant to salt spray and weathering, and stable at elevated temperatures. It can be applied with the conventional techniques used for industrial organic coatings. The resin may be formulated in a variety of colors.

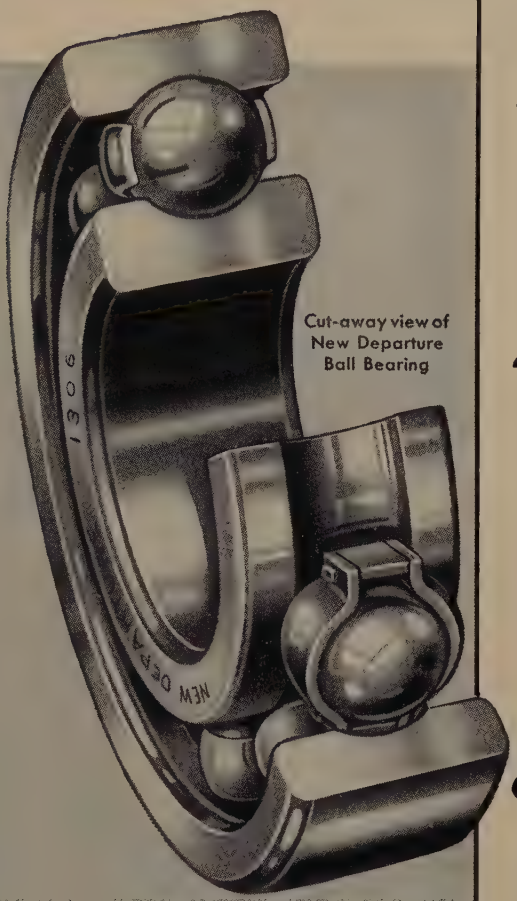
PLASTICS APPLICATIONS

ONE of the largest plastics cabinets ever molded for the television industry, molded in two parts and weighing 11 lb, was produced at Pittsfield for assembly at Syracuse (N. Y.).

There are no metal dispensing parts in a crystal-clear paper-cup holder produced for the Dixie Cup Company. Cups are easily inserted through the bottom opening and are held in place by plastics lugs. The holder is injection-molded of polystyrene compound, in a manner that eliminates flow lines and gas marks.

Electrical and Allied Developments in 1949 did not forget the fishermen. There is a new fly-box incorporating a rotating alnico permanent magnet which holds three dozen flies in place in the strongest breeze, yet rotates in either direction for easy selection of a favorite fly. Designed and produced at Pittsfield for the Charles F. Orvis Company of Manchester (Vt.), the box is approximately 4 in. square, constructed of durable transparent polystyrene, with a special snap-hinge.

The bare facts about ball bearings



Cut-away view of New Departure Ball Bearing

Rugged New Departure Ball Bearings lick friction with free-rolling, tough, forged steel balls.

They welcome today's more exacting requirements of higher speeds, heavier loads and *continued* precise positioning of moving parts.

And . . . most important of all, New Departure, world's greatest ball bearing maker, meets your particular problems with a vast fund of experience and *original thinking.*

Nothing Rolls Like a Ball

NEW DEPARTURE
BALL BEARINGS

1

Nothing Rolls Like A Ball. It is nature's favorite, strongest form. Having no ends, it rolls freely in any direction.

2

Under heavy compression it deforms slightly and then resumes its original form. Made of the toughest, most resilient steel known to man, the New Departure steel ball is of uniform structure throughout.

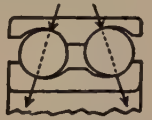
3

Its inherent resistance to load is greatly increased by curved raceways which, under load, are nearly filled by an arc of the ball. "Point contact" talk is the bunk. Actually, its contact is an ellipse, like this: ⬬

4

This is how a ball resists thrust (axial loads) as well as radial loads — like a bicycle on a banked track.

5



Put two rows of balls together, and you can support thrust and radial loads from any direction. They may be in one single bearing or in two separate bearings.

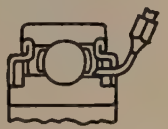
6

Unlike other types of rolling elements, the ball need not be forced to travel in the proper direction. Function of separator is merely to keep balls spaced. Contact is at poles (point of slowest rotation—least friction.)

7

Only ball bearings may be self-sealed with integral closures of felt and metal. In average conditions New Departures are lubricated for life. Other type bearings cannot maintain precise "inter-fitment" needed to maintain efficient sealing.

8



Newest new departure *by* New Departure: Lubrication in new sealed bearings may be revitalized by injecting with hollow needle on pressure oiler—without removal of seals or need for nipples, grease passages, plugs.

NEW DEPARTURE • Division of General Motors • BRISTOL, CONN. • Branches in DETROIT • CHICAGO • and Other Principal Cities

SCIENCE NEWS FROM GENERAL ELECTRIC

improved mass spectrometer

for direct recording over a wide range

The improved General Electric mass spectrometer automatically and accurately records mass concentrations over the mass range of 1 to 350. The instrument is ideal for atomic research and for analysis in chemical and petroleum industries. Request descriptive bulletin GEA-4907. General Electric Company. Schenectady, New York.

J. G. Neuland, G-E engineer, tests one of the improved instruments.

GENERAL ELECTRIC

687-4

HIGH LIGHTS AND SIDE LIGHTS

Fluorescent Street Lighting

A fluorescent street light has been announced which engineers say provides the most comfortable light yet devised for motorists and pedestrians. The light will be used for public demonstration by electric power companies and municipalities, to enable them to investigate at first hand the possibilities of fluorescent street lighting and to compare its performance and characteristics with present-day lighting.

The new street light is a cigar-shaped aluminum unit in which two pairs of eight-foot-long fluorescent lamps are mounted. Two long, highly polished reflectors, placed back to back, direct the light from these lamps through clear plastic windows to the street pavement.

These fixtures, mounted on poles over the roadway, provide light that is far less glaring than the standard type because it comes from a larger area, and because the lamps are almost entirely concealed from the motorist's view.

Besides softer light, major advantages are high-efficiency lamps with relatively long life, and better visibility for motorists, particularly when pavements are wet.

While many problems must be solved before this fluorescent lighting can be considered economical for widespread use, it is believed that these problems can be solved after the industry has had an opportunity to analyze the results of pilot installations.

Fluorescent lighting is well-suited for tunnels and underpasses, and for bridges, viaducts, and airport approaches where lights mounted at shoulder level are desirable. For these uses, two specially designed fixtures, one for tunnels and the other for shoulder-high mounting along bridges and viaducts, have been developed. Fluorescent lighting will be installed in the two 9000-ft tubes of the Brooklyn-Battery Tunnel now under construction.

Amplidyne-controlled Lift Bridge

Stickel Memorial Bridge, the world's first amplidyne-controlled vertical-lift bridge, was recently opened to traffic across the Passaic River. The 1375-ton 222-ft span is here shown being raised by electric drive with an amplidyne control system

Cloud Analyzer

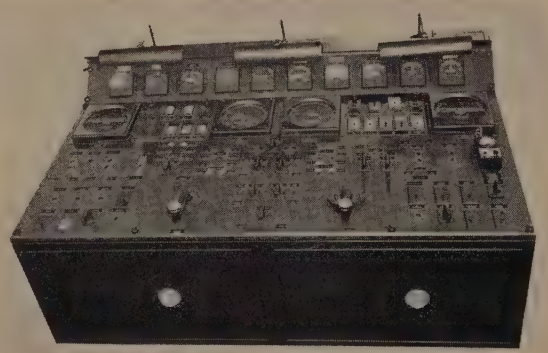
The thickness, height, and density of clouds can now be measured and recorded by the "cloud analyzer."

The device, developed for the U.S. Navy, is carried aloft by a weather balloon, which climbs into the upper atmosphere at a speed of about 1200 feet per minute.

Carrying its own tiny transmitter, the cloud analyzer sends weather data to a ground receiver at the rate of 120 times per minute. It gives the height of a cloud at its summit and base, and also indicates density of a cloud. Other instruments carried by the balloon provide temperature, air-pressure readings, and relative humidity.

Basic part of the instrument is a piece of string saturated with a salt solution. As electricity is sent through it, a resistance reading is given indicating the liquid water content of a cloud. If the balloon passes through a dense cloud, the string picks up moisture and becomes a better conductor of electricity. A low resistance indicates water, or rain. An increase in resistance indicates a decrease in the amount of liquid water in the air.

(Concluded on next page)



Small control units operated from this master control desk provide a wide range of speeds —as high as 100 ft in 105 seconds—yet keep the bridge level while it is raised or lowered

BETTER REFERENCE FOR YOU WITH A

1949 BOUND VOLUME

Just send us your single copies of 1949 and we will send you a complete volume, with index, bound in our attractive gold stamped, black half-morocco leather binding, with cloth sides.

A complete file for constant reference in a beautiful, durable binding for only $6.00 postpaid. To points outside the U.S.A., $1.00 postage.

GENERAL ELECTRIC REVIEW
Schenectady 5, N. Y.

SEXTON CAN COMPANY
Incorporated
Everett Massachusetts
Manufacturers of
Ash Barrels
Kitchen Waste Cans
Underground Garbage Receivers
CAPACITOR CASES
both Fabricated and Deep Drawn
FIVE GALLON
Open and Closed Top Shipping Containers
METAL STAMPINGS
SPECIAL SHEET METAL WORK

HIGH LIGHTS (Continued)

Carrying eight pounds of delicate instruments, the weather balloon climbs to about 75,000 feet, where it bursts. The instruments are lowered to the ground by parachute.

The antenna of the ground control system "tracks" the balloon automatically, even on board a rolling ship. Data received from the balloon are translated into direction and height, so that the antenna is always pointed toward the balloon, regardless of the movements of the ship or the balloon.

Information received from the balloon is automatically recorded on moving strips of paper. The ground equipment also records information from which wind velocity and direction can be determined.

Long-probe Radiation Detector

A new radiation detector soon may be helping atomic researchers to protect themselves against possible dangers from radiation.

Called the "long-probe gamma survey meter," the instrument has a "nose" four feet long, which permits detection of radiation from a distance. It can be used for any type of radiation metering, such as monitoring areas in which radioactivity is suspected. The accompanying photograph shows it in use monitoring a laboratory safe containing radioactive isotopes, which are enclosed in a heavy metal canister and surrounded by lead bars to prevent possible radiation exposure.

An electronic tube is located at the tip of the long probe. Attached to the tube is a phosphor, which gives off light in the presence of radioactivity.

Monitoring a laboratory safe with the long-probe gamma survey meter

Light from the phosphor, acting upon the electronic tube, is converted into electrical energy. At the other end of the instrument, a meter, activated by amplified current from the tube, registers the intensity of radiation exciting the phosphor four feet away.

Power is supplied by batteries, which are packed in a box and carried over the operator's shoulder.

Sound Quality

For many years there have been instruments for measuring the loudness and frequency of sounds, but not the constant changing quality of sound. It is considered possible that this tiny wavering accounts for characteristics of certain sounds that the ear can detect but which instruments have not been able to measure.

Cricket noises coming through a window are not ordinarily loud enough to register on most sound-measuring instruments, yet they have an effect on human ears far out of proportion to their energy. Up to the present time, there have been no instruments capable of distinguishing between a note played on a Stradivarius and the same note played on an ordinary violin.

Recent reports indicate that engineers are now beginning to study sounds in terms of their differing quality as well as in terms of loudness and frequency at a given point in time. New understanding of sound problems and new advances in sound engineering are expected as a result.

FOR THE PURCHASE OR SALE OF IRON & STEEL SCRAP

LURIA BROTHERS & COMPANY, INC.

Have been Serving Industry SINCE 1889

Main Office
LINCOLN-LIBERTY BLDG.
Philadelphia 7, Pennsylvania

Yards
LEBANON, PA.
READING, PA.
DETROIT (ECORSE), MICH.
MODENA, PA.
PITTSBURGH, PA.

Branch Offices

BIRMINGHAM, ALA. Empire Bldg.
CLEVELAND, O. 1022 Midland Bldg.
NEW YORK, N.Y. Woolworth Bldg.
BOSTON, MASS. Statler Bldg.
DETROIT, MICH. 2011 Book Bldg.
PITTSBURGH, PA. Oliver Bldg.
BUFFALO, N.Y. Genesee Bldg.
HOUSTON, TEXAS Cotton Exchange
PUEBLO, COLO. Colorado Bldg.
CHICAGO, ILL. 100 W. Monroe St.
LEBANON, PA. Luria Bldg.
READING, PA. Luria Bldg.
ST. LOUIS, MO. 2110 Railway Exchange Bldg.
SAN FRANCISCO, CAL. Pacific Gas & Elec. Co., Bldg.

ASSOCIATED ELECTRICAL INDUSTRIES
• LIMITED •

British Thomson-Houston Co., Ltd.
Edison Swan Electric Co., Ltd.
(*Incorporating Harcourts Limited*)
Ferguson Pailin Limited
Hotpoint Electric Appliance Co., Ltd.
(*Incorporating International Refrigerator Co., Ltd. and Premier Electric Heaters Ltd.*)
Metropolitan-Vickers Electrical Co., Ltd.
Metropolitan-Vickers-GRS. Ltd.
Newton Victor Ltd.

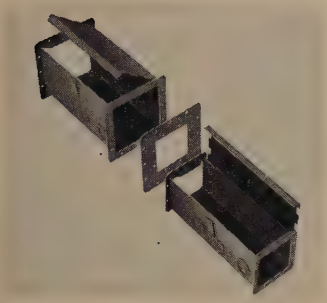
• •

Agents and Licensees of the
GENERAL ELECTRIC Co., U.S.A.
for the United Kingdom.

A3951

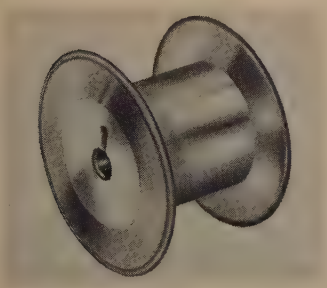
NEW PRODUCTS: AND WHAT THEIR MAKERS HAVE TO SAY ABOUT THEM

Reducer Bushing



A reducer bushing that provides a simple way to connect a 6-in. wireway to a 4-in. size. The reducer is made of heavy metal 7½-in. square with a 4-in. opening in the center. Fastened by bolts to the flanges of the wireways, this reducer forms a rigid connector between the two sizes. The sides of the wireways have knockouts, ranging in diameters from 1 to 2½ in., located 3 in. apart. A hinged cover facilitates easy access for wiring.—*Keystone Mfg. Co., Center Line, Mich.*

Plastic Spool



A practical plastic spool for the wire industry. A new-type filler, combined with a special thermosetting resin have the properties desirable in a plastic wire spool. Resistance to impact or chipping must necessarily be high in such a spool, since it is ordinarily subject to considerable rough handling. These spools are molded in one piece; thus head and barrel form one unit with high rigidity to resist deflection. The one-piece construction also eliminates the possibility of wire trapping. Another feature is that brand identification by color can be achieved easily by means of the color combination of the entire spool. Because color is integral with the plastic, it will not chip or wear off.—*Hubbard Spool Co., 1622 W. Carroll Ave., Chicago 12, Ill.*

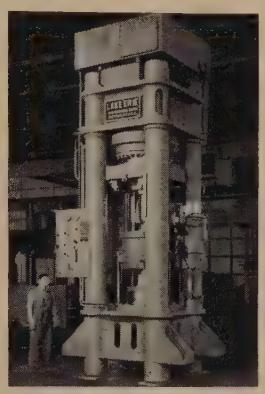
Selector Switch

A new master selector switch of the rotating type for 24-volt remote-control wiring systems. A combination selector and control switch, it enables the user to select any one of nine different circuits and operate them separately or, with one sweep, to turn on or off all nine circuits.

For residential users, the switch will be useful in bedrooms, kitchen, entrances, etc. Industrial users will find it useful to control various groups of lights, small motors, or other fixture circuits. It would also be useful for controlling lights in motor courts, parking lots, bowling alleys, small baseball diamonds, etc.—*General Electric Co., Construction Materials Dept., Bridgeport 2, Conn.*

Extrusion Press

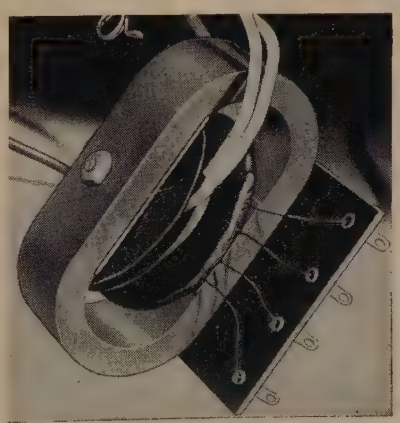
A series of lead extrusion presses for cable and hose encasing have many new design features. They are fully automatic, substantially reduce labor costs (high extrusion rates), and require a minimum amount of floor space. The largest press has a capacity of 2500 tons, and it is fitted with an automatic billet loader. Two other types have capacities of 1000 and 500 tons respectively, and they have either automatic



or manual billet loaders as required. All of the presses are of the self-contained, 4-column, downstroke type.—*Lake Erie Engineering Corp., Buffalo 17, N. Y.*

Powdered-iron-core Transformer

A new horizontal output transformer utilizing an elliptic closed core with center slug, made of powdered-iron material known as Croloy 597. With higher permeability, the core mass can be kept at a minimum, effecting cost reductions in copper windings, labor, and use of paper-insulated layer-



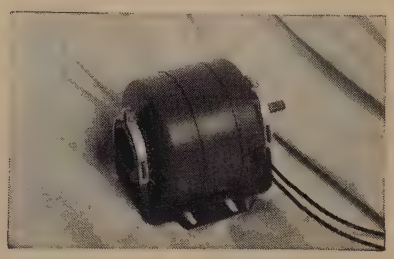
wound coils. Properly designed coils in conjunction with these cores permit TV set designers to operate a 16-in. picture tube with a single rectifier stage at an anode voltage of 14 kv, yet with adequate sweep for satisfactory performance.—*Henry L. Crowley & Co., Inc., West Orange, N. J.*

Synthetic Wax

A new synthetic wax, Ceramid, chemically is an alkyl stearamide. Hard, light yellow in color, and insoluble in water, the wax melts between 79.5 to 80.5 C. Indicated among its uses are: as protective coatings and films (when emulsified it gives a white matt finish which can be rubbed to give a high polish); as an antitack agent for organisols; as a mold lubricant to prevent sticking of finished articles; as a flatting or gloss-reducing agent; as a blend with other waxes; and as waterproofing for textiles, paper, and leather.—*Glyco Products Co., Inc., 26 Court St., Brooklyn, N. Y.*

Unit-bearing Motors

A new line of lifetime oil-lubricated Type KSP shaded-pole motors designed for operation in any position. The motors can be used as drives for exhaust or cooling fans, evaporative coolers, unit heaters, condenser cooling, and space heaters, as well as for small pumps, agitators, and blowers.



In addition to the new lubricating system, which continuously feeds the bearing with filtered oil, other features include greater strength on direct-connected loads provided by the unit-bearing construction on the shaft end of the motor; treated stator windings of Formex insulated wire; and vibration-absorbing resilient end rings resistant to oil and aging.

The motors have either open or totally enclosed construction, and ratings range from 1/40 hp through 1/12 hp at 115 or 230 volts, 1050 or 1550 rpm, 60 cycles.—*General Electric Co., Apparatus Dept., Schenectady 5, N. Y.*

Capacitors

An improved midget self-healing metallized paper capacitor named Metalite in both hermetically sealed and cardboard tubular designs. Available in voltage rat-

ings up to 600 volts and supplied with glass-to-metal hermetic terminal seals, they possess high insulation resistance at high temperatures. Special types can be designed to meet specifications for desired applications.—*Astron Corp., 900 Passaic Ave., East Newark, N. J.*

TRADE LITERATURE

ADJUSTABLE SPEED—A series of five publications on adjustable speed, the first of which presents a concise summary of specific benefits that the various branches of industry can expect from properly applied adjustable speed. Consideration is given to selecting adjustable-speed drives, and the range of application and performance features of package units is described. The others contain descriptive and application data for the specific equipments involved. "Adjustable Speed," twenty-four pages, GEA-5334; "Adjustable-speed ACA Motors," eight pages, GEA-4883A; "Speed Variator," eight pages, GEA-5335; "Electronic Speed Variator," eight pages, GEA-5336; and "Thy-Mo-Trol Adjustable-speed Drives," twenty pages, GEA-5337—*General Electric Co., Apparatus Dept., Schenectady 5, New York.*

BALL BEARINGS—A booklet describing and illustrating five distinct types of self-sealed and lubricated-for-life ball bearings designed for belt and trolley conveyors, foundry-mold car wheels, and similar applications. Dimensional and load-capacity data are included. Sixteen pages. Code C.—*New Departure, Div. General Motors Corp., Bristol, Conn.*

CHEMICAL FEEDER—Describes the operation of the Feed-Rator chemical feeder for liquids and gases. A list of chemicals the feeder will handle, typical installations, and specifications are included. Four pages. Catalog 62.—*Fischer & Porter Co., Hatboro, Penna.*

COAL PREPARATION—A booklet, mainly pictorial, showing how various phases of electrification improves quality and cuts costs at three modern coal preparation plants. Thirty-two pages. GEA-5308. *General Electric Co., Apparatus Dept., Schenectady 5, N. Y.*

COMBUSTIBLES RECORDER—The textual explanation of the operation of a combustibles recorder, an electronic-type instrument, is supplemented by drawings and photographs. Typical applications to boiler and industrial furnaces, atmosphere producers, rotary kilns, and chemical processes are illustrated. Sixteen pages. Bulletin No. 150-A.—*Bailey Meter Co., 1050 Ivanhoe Road, Cleveland 10, Ohio.*

HEATERS—Two catalogs each containing descriptions, specifications, illustrations, and typical installations of Electromode heater units, as well as other helpful information concerning heating by electricity. Eight pages, Industrial Catalog EC-62. Four pages, Domestic Catalog EC-63.—*Electromode Corp., 45 Crouch St., Rochester, 3, N. Y.*

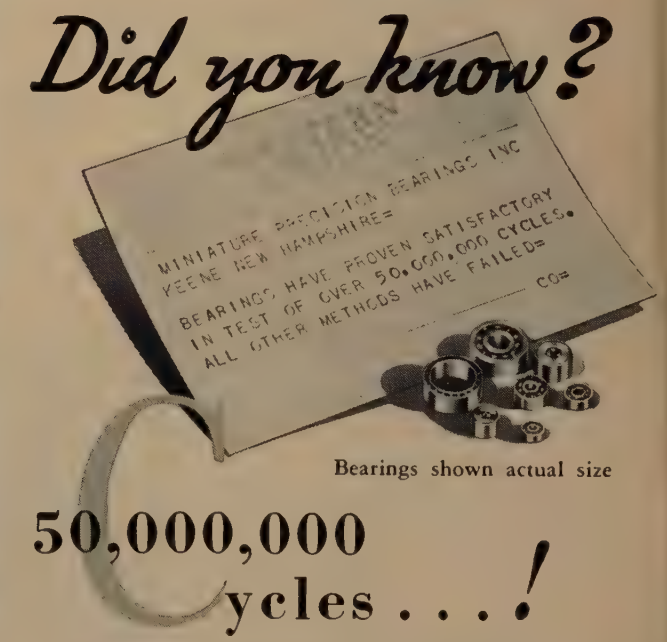
RELAYS—Contains useful information on seven types of magnetic relays for industrial and general-purpose control applications including technical data on relay ratings, dimensions, illustrations, coil specifications, and applications. Twelve pages. Catalog No. D-20A.—*Ward Leonard Electric Co., Mt. Vernon, N. Y.*

SOLDERING—Describes an extensive line of soldering products—gasoline and kerosene blow torches, self-generating alcohol blow torches, electric soldering irons, solder, splicer's furnaces, etc. An illustration accompanies each description. Twenty-four pages. Catalog No. 85.—*P. Wall Manufacturing Co., Grove City, Pa.*

TELEVISION— Of modern design with numerous thumbnail drawings to clarify and dramatize the text, this booklet's main theme is an elementary explanation of television—its production, reception, and history; how the networks are made; and other similar topics. The concluding section is devoted to pertinent questions and answers presented in dialogue style. Titled "Here's How To Be A Television Expert." Twenty-three pages.—*Motorola, Inc., Chicago 51, Ill.*

WIRING ACCESSORIES—Contains data on splice caps and Termend lugs, for wire splicing and terminating; box connectors, for metallic and nonmetallic sheathed cable; both plain and insulated conduit bushings; conduit locknuts; knockout plugs; terminal blocks; etc. Illustrations, dimensional data, and application instructions are included. Twelve pages. (Supplement Catalog Sheet 10A-11) Catalog Sheet 8.—*Buchanan Electrical Products Corp., 1290 Central Ave., Hillside, New Jersey.*

ILSCO
Connectors
Accessories
SOLDER LUGS . . . SERVICE CONNECTORS . . . FUSE CLIPS . . . TERMINALS . . . SHADING COILS, ETC.
NEW 80-page catalog now ready showing over 2,000 Ilsco items in color.
WRITE FOR CATALOG TODAY
ILSCO
COPPER TUBE & PRODUCTS, Inc.
CINCINNATI 27, O.



Bearings shown actual size

50,000,000 cycles . . . !

For applications where you can't afford to fail . . . MINIATURE PRECISION BEARINGS manufactures over 50 different types and sizes of miniature ball bearings.

Catalog in Sweet's PD File or mailed immediately on request.

MPB MINIATURE Precision BEARINGS
INCORPORATED
KEENE, NEW HAMPSHIRE, U.S.A.

BOOK REVIEWS

(Available books may be purchased through the GENERAL ELECTRIC REVIEW for domestic delivery; none sent on approval.)

IGH MOLECULAR WEIGHT ORGANIC COMOUNDS

. E. Burk and Oliver Grummitt, Editors—nterscience Publishers, Inc., New York. 949. 330 pp. $5.50.

The sixth volume of Frontiers in Chemisy, based on the annual lecture series held at Vestern Reserve University, consists of six hapters: (1) Polymerization in Suspension nd Emulsion, by W. P. Hohenstein and . Mark; in this chapter the most recent echniques and ideas concerning suspension nd emulsion polymerization have been rought together. (2) Osmometry and iscosity of Polymer Solutions, by W. J. adgley and H. Mark; a few of the newer deas in addition to the usual treatment are onsidered here. (3) The Nature of Elasomers, by H. L. Fisher; here only the hemical nature of elastomers is conidered. (4) Aspects of the Structure and eactions of Proteins, by J. T. Edsall; his chapter is concerned with mode of nkage, amino-acid content, acid-base quilibria, size and shape, electrical properies, and solubility of proteins. (5) Condensaion Polymerization and Constitution of ondensation Polymers, by P. J. Flory; his excellent chapter is a reprint of Dr. aul J. Flory's article published in *Chemical eviews*, vol. 39 (1946). (6) Physical and hemical Structure of Phenoplasts, by . S. Carswell; here is a short treatment on yet controversial subject.

The book will be useful to chemists with some knowledge of polymers who wish to keep abreast of the field. Each chapter contains a considerable number of literature references.

H. TRACY HALL

RADIOACTIVE MEASUREMENTS WITH NUCLEAR EMULSIONS

Herman Yagoda—John Wiley & Sons, Inc., New York. 1949. ix+356 pp. $5.00.

The use of photographic emulsions as a means of investigating radioactivity has been accelerating in recent years. This in turn has instigated a great deal of work on the improvement of sensitivity. Progress has been phenomenal, and the most recent emulsions record minimum ionization with ease.

This means they are as sensitive as Wilson cloud chambers, and it is possible to follow the trajectory of an electron of any energy through the emulsion. The attractiveness of the method lies in the simplicity of the techniques involved and the moderate cost of equipment. It is therefore gratifying to see a comprehensive work devoted to this important tool.

Dr. Yagoda has undertaken the description of the technique as used in applications to biology, radiochemistry, metallurgy, mineralogy, and nuclear physics, the fields in which the emulsions have found their major use. Because of the range of material included in such a work it was not possible to cover any field in the detail which a particular experimenter might desire, and the book is offered more as a guide to the types of information which can be gained through the use of the technique.

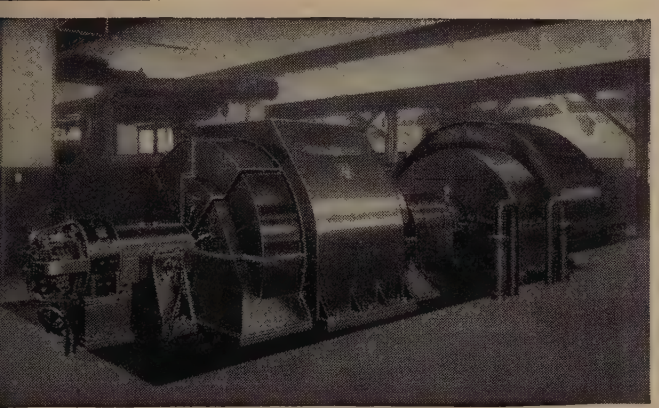
This volume should be of value to anyone who is working in the field or who is interested in the methods involved. To the uninitiated it offers complete information concerning methods for preparing materials for exposure, precautions necessary for minimizing pseudophotographic effects, and procedures for processing emulsions of various types. To the more experienced researcher the book should prove of value because of its unusually complete bibliography of more than 700 items, each of which is treated at an appropriate point in the text.

DONALD H. MILLER

ELEMENTS OF SOUND RECORDING

John G. Frayne and Halley Wolfe—John Wiley & Sons, Inc., New York. 1949. vii+686 pp. $8.50.

This timely book is an outgrowth of a course given by the authors at the University of California in connection with the war training program. It is intended to treat the



,000 hp Synchronous Motor, manufactured at C-G-E Peterborough Works, driving a centrifugal compressor at a large Canadian nickel mine.

In Canada . . .

ten factories manufacture General Electric products. 30 engineering and sales offices and 19 warehouses are located from coast-to-coast to serve you.

CANADIAN GENERAL ELECTRIC CO LIMITED

rdney • Halifax • Saint John • Quebec • Chicoutimi • Trois Rivieres • Sherbrooke • Montreal • Ottawa • Toronto amilton • St. Catharines • London • Windsor • Noranda • New Liskeard • Sudbury • Timmins • Fort William innipeg • Brandon • Regina • Saskatoon • Lethbridge • Edmonton • Calgary • Trail • Kelowna • Vancouver • Victoria

DO YOU KNOW?

—that a PILOT LIGHT CAN IMPROVE YOUR PRODUCT . . . add attraction—safety—service?

Ask DIALCO — what lamp to use — how to use it — what it will do — what it will cost

THIS MAY BE THE ONE

Designed for low cost NE-51 Neon

• Built-in Resistor • Patented
• U/L Listed • Rugged

Catalogue Number 521308 — 997 for 110 or 220 volts.

SAMPLES for design purpose NO CHARGE

NEW! Write for the "HANDBOOK OF PILOT LIGHTS."

Write us on your design problems.

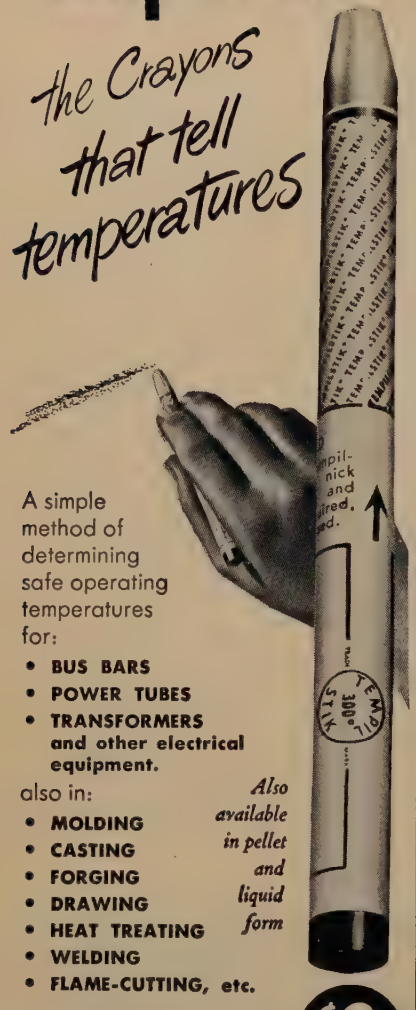
Foremost Manufacturer of Pilot Lights

The DIAL LIGHT COMPANY of AMERICA

900 BROADWAY, NEW YORK 3, N. Y.

Tempilstiks°

the Crayons that tell temperatures



A simple method of determining safe operating temperatures for:

- **BUS BARS**
- **POWER TUBES**
- **TRANSFORMERS and other electrical equipment.**

also in:

- **MOLDING**
- **CASTING**
- **FORGING**
- **DRAWING**
- **HEAT TREATING**
- **WELDING**
- **FLAME-CUTTING, etc.**

Also available in pellet and liquid form

It's this simple: Select the Tempilstik° for the working temperature you want. Mark your workpiece with it. When the Tempilstik° mark melts, the specified temperature has been reached.

$2 each gives up to 2000 readings

Available in these temperatures (°F)				
113	263	400	950	1500
125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000
250				

FREE—While we cannot supply free Tempilstiks°, we will be glad to send you sample Pellets or sample Tempilaq° *(liquid form)* for trial under your actual working conditions. Be sure to state the temperature of interest to you.

Tempil° corp.
134 WEST 22nd STREET
New York 11, N. Y.

BOOK REVIEWS (Continued)

problem of sound recording from the operating rather than the developmental engineer's viewpoint. While in no way detracting from the book, the arrangement shows evidence of its derivation from lecture material rather than the more logical presentation of a planned treatise.

Existing practice is ably outlined and the theoretical background necessary for a useful understanding is discussed. References at the end of each chapter mention the source material. The long experience of the authors eminently qualified them to offer what is probably the first comprehensive book in this field. It is hoped that at some future date they will extend their present work to sound reproduction.

The earlier chapters briefly review fundamentals: general acoustics, mechanics, electronics, as well as such required electrical, acoustical and mechanical components as might be needed by the students or those not entirely familiar with this specialized field. Such material was, of course, highly important to the original purposes for which the material was prepared and, in the interest of completeness, is useful to the casual student. However, since it is not explicitly used in later chapters, the book might have been shortened by its omission.

The later chapters (starting with Chapter 11) cover systems for disk, film, and magnetic recording. They are a veritable storehouse of information for the practicing engineer and ably report theory, practice, and devices upon which sound recording is based. In addition, means of measurement, test and calculation, causes of distortions, theory of components and equipment are also treated.

The work is copiously illustrated by diagrams, photographs, curves, charts, etc. Mathematical treatments have been included where these would assist materially in providing a quantitative understanding of the various points in question.

ELLSWORTH D. COOK

ENGINEERING LAMINATES

Albert G. H. Dietz, Editor—John Wiley & Sons, Inc., New York. 1949. viii+797 pp. $10.00.

A compilation of application and engineering data on a wide variety of laminated materials, *Engineering Laminates* indicates the potentialities of combining single materials into new and useful laminated combinations. The editor has drawn on a large number of contributors from industry, government laboratories, and universities for the wealth and diversity of material presented.

Laminates are popularly identified with such materials as resin-bonded fabrics, wood veneers, and plywoods. While such types of materials are of great importance, the scope of the book goes far beyond these familiar structures. The author has attemped to see how many unusual combinations of engineering usefulness could be grouped under the general heading of laminates. As a result, the book's coverage ranges from thermostat bimetals to stressed skin sandwich constructions; from alloy-coated steel to bulletproof safety glasses.

The book opens with a detailed mathematical analysis showing the behavior of the various classes of laminates under a variety of mechanical forces. While the mechanical properties of each material are discussed under the separate headings, this general mathematical treatment is fundamental to the use of laminates for structural purposes.

Outlining the general field of use of laminates, they may be made to yield high strength-to-weight ratios as in certain kinds of sandwich construction. One may easily manufacture complicated shapes with compound curves, as in the use of polyester-bonded fabric laminates. Corrosion resistance may be obtained at low cost by welding thin sheets of corrosion-resistant alloys to the base metal and rolling the composite to the required thicknesses. Laminates for thermal insulation may be made with strong exteriors and insulating cores. Other specialized applications are considered.

Of particular mention is the chapter on adhesives and bonding agents, which covers the development of modern adhesives from the earliest animal glues to the most recent advances in synthetic materials. This chapter is a review of modern plastics describing the manufacture and application of phenolic, melamine, polyester, and silicone laminating and casting resins. These materials are of interest outside the strictly laminating field, and the review is recommended as a good reference to the subject in its own right.

The rather specialized field of electrical insulating materials is covered in general but not so exhaustively as other subjects.

With its wide coverage of laminated structures, this should be a useful reference for those who wish to be up-to-date in a rapidly expanding art. The work is recommended for architects, designers, and engineers working with materials of construction.

A. D. COGGESHALL

ANGULAR POSITION TRANSMITTERS

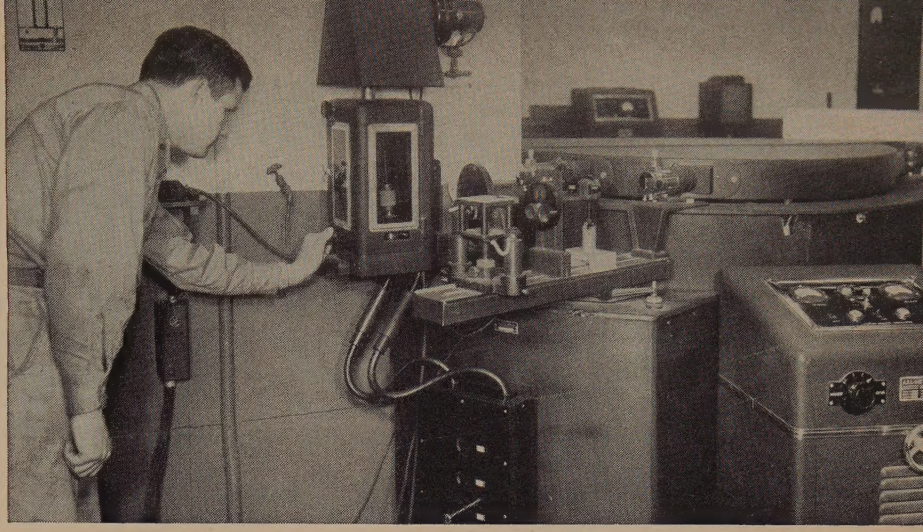
The Giannini line of angular position indicators for remote indication has recently been broadened. To the Microtorque, Minitorque and Minipot potentiometer family has been added a selection of inductance type transducers. These instruments are available in a wide variety of angular ranges and linear or non-linear signal variations can be provided.

Size — 1" x 2". Weight — 2 oz.

Write for detailed information.

G. M. Giannini & CO. INC.
254 W. COLORADO STREET
PASADENA 1, CALIFORNIA

Only the BEST pass these tests



The spectrograph provides one of the most efficient means for precise metallurgical control. Samples taken from a heat in the Driver-Harris melting furnaces are analyzed so rapidly by means of this apparatus, that a complete analysis can be obtained before the next heat is ready for pouring. Thus any necessary adjustments can be made immediately—an outstanding advantage in controlling the constituent elements of alloys being produced to extremely close specifications. The operator is here seen adjusting the size of the analytical gap in the arc-spark stand of the Driver-Harris grating spectrograph at the start of an exposure.

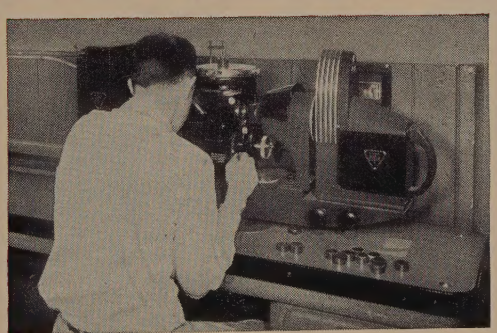
The quality of any manufactured item depends upon a number of factors, but on none so much as "inspection". And here, at Driver-Harris, we give top priority to inspection.

Through every stage of manufacture, precise metallurgical checks and controls are systematically applied to D-H Alloys to insure quality and uniformity that are unsurpassed—recognized the world over.

We have had 50 years' experience in continuous alloy research and manufacture. Every piece of D-H wire, ribbon or strip, and every casting embodies advantages such as only half a century of accumulated know-how can provide.

Whatever your requirements for electrical resistance and heat-resisting alloys, send us your specifications. We shall be glad to make recommendations, and supply you with the alloy best suited to your needs.

s operator is viewing the projection of a series spectrograms, and is about to measure the ensity of specific spectral lines to determine the antity of certain chemical elements in the mples being analyzed.



The research metallograph, the ultimate in metallurgical microscopes, is applied to both research and quality control at Driver-Harris.

A view in the Driver-Harris chemical laborat —fully equipped for all standard types volumetric, gravimetric and colorime analyses.

FIFTIETH ANNIVERSARY — SPECIAL PURPOSE ALLOYS SINCE 1899 — D/H — TRADE MARK REG. U. S. PAT. OFF.

*Makers of over 80 alloys for the electronic, electrical and heat-treating fields—including world-famous Nichrome**

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

*T. M. Reg. U. S. Pat. Off.

General Electric Apparatus has world-wide distribution

General Electric apparatus is sold around the world except in the United States, Hawaii, Canada, and the Canal Zone, by the International General Electric Company through the following representatives:

Africa—Portuguese Africa
General Electric Portuguesa, S.A.R.L.
Apartado 316, Lisbon, Portugal

Anglo-Egyptian Sudan
Eastern Electric Co. (S.A.E.)
33 Malika Farida St., Cairo, Egypt

Argentina
General Electric, S. A.
Calle Tucumán 117 (R-34), Buenos Aires

Australia
Australian General Electric Proprietary, Ltd.
95 Clarence St., Sidney

Austria
"Intropa"
Rotenturmstrasse 25, Vienna 1

Belgian Congo
S.E.M. Soc. D'Electricité et de Mécanique
Leopoldville, Kalina

Belgium
S.E.M. Soc. D'Electricité et de Mécanique
42 Dock, Ghent

Bolivia
International Machinery Co. (Bolivia) S.A.
Mercado 316, La Paz

Brazil
General Electric, S. A.
Avenida Almirante Barroso 81, Rio de Janeiro

Bulgaria
New York Commodities Corp.
60 Broad St., New York 4, N.Y., U.S.A.

Chile
International Machinery Co.
Casilla 107-D, Santiago, Chile

China
Andersen, Meyer & Co., Ltd.
21 Yuen Ming Yuen Road, Shanghai

Colombia
International General Electric, S.A., Inc.
Apartado de Correo 2552, Bogotá

Costa Rica
Compañía Constructora Eric C. Murray, S.A.
Apartado 1867, San José

Cuba
General Electric Cubana, S.A.
O'Reilly 414, Havana

Denmark
AEG Dansk Elektricitets Aktieselskab
Vester Farmagsgade 41, Copenhagen V

Dominican Republic
Carribbean Motors Co., C. por A.
J. D. Alfonseca esq. a Padre García,
Ciudad Trujillo

Ecuador
Grace y Cía. S. A. Comercial
Malecón 1302 y General Elizalde, Guayaquil

Egypt
Eastern Electric Co. (S. A. E.)
33 Malika Farida St., Cairo

El Salvador
Munguía P. & Cía.
4a. Av. Norte y 1a. Calle Oriente, San Salvador

England
International General Electric Co. of New York, Ltd.
Crown House, Aldwych, London W.C. 2

Associated Electrical Industries, Ltd.
Crown House, Aldwych, London, W.C. 2

France
International General Electric Co., Inc.
79 Ave. Des Champs-Elysées, Paris (8e)

Cie Francaise Thomson-Houston
173, Boulevard Haussman, Paris (VIII)

Alsthom
38 Avenue Kléber, Paris (16e)

Germany
Envoy International Corp.
745 Fifth Ave., New York 22, N.Y., U.S.A.

Greece
General Electrotechnical Co.
9 Paparigopoulo St., Athens

Guatemala
Emilio Selle
7a Ave. Sur No. 6, Guatemala City

Iceland
Electric H/F
6 Tungata, Reykjavik

India
International General Electric Co., (India) Ltd.
Graham Rd., Ballard Estate, Bombay No. 1

Indonesia
International General Electric Co., Inc. of Java
Koningsplein Noord 22, Batavia

Iran
General Iranian Electric Co.
Lalezar Ave., Teheran

Iraq
F. A. Kettaneh & Co., Ltd.
Al Raschid St., Baghdad

Israel
British Thomson-Houston Co., Ltd.
26 Gruzenberg St., Tel-Aviv

Italy
Compagnia Generale di Elettricita
Via Bergognone, 34, Milano

Japan
International General Electric Co., Inc.
Room 319, Tokyo Hotel, Tokyo

Lebanon
F. A. Kettaneh
Avenue des Francais, Beyrouth

Malaya
The Borneo Co., Ltd.
143-149 Fenchurch St., London, E. C. 3, England

Mexico
General Electric, S.A.
San Juan de Letrán No. 37, Mexico, D.F.

Miquelon
B. Leroux-Deschamps
Miquelon, North America

New Zealand
National Electrical & Engineering Co., Ltd.
286-288 Wakefield St., Wellington

Nicaragua
D. A. McGregor, Sucesores
1a. Calle Sureste No. 103, Managua

Panama
International General Electric Co., Inc.
Calle 29, Este No. 24, Panama

L. R. Sommer
Balboa, Canal Zone

Guardia & Cía., S.A.
Avenida Justo Arosemena y Calle 29 Este, Panama

Paraguay
General Electric, S. A.
Calle Tucumán 117 (R-34), Buenos Aires, Argentina

Peru
International Machinery Co.
Lampa and Ucayali Sts., Lima

Philippine Islands
General Electric (P.I.), Inc.
120 13th St., Port Area, Manila

Poland
New York Commodities Corp.
60 Broad St., New York 4, N.Y., U.S.A.

Portugal
General Electric Portuguesa, S.A.R.L.
Rua do Norte 5, Lisbon

Puerto Rico
International General Electric, S.A., Inc.
310 San Francisco St., San Juan

Rumania
New York Commodities Corp.
60 Broad St., New York 4, N.Y., U.S.A.

Saint Pierre
B. Leroux-Deschamps,
Saint Pierre, North America

Saudi-Arabia
The Arabian Trading Co.
Jeddah, Saudi-Arabia

Abdulrehman Algosaibi
Bahrain (Persian Gulf)

Bader Al Mulla & Co.
Kuwait (Persian Gulf)

South Africa
South African General Electric Company, Ltd.
Richards & Webber Sts., Selby, Johannesburg

Spain
General Eléctrica Española, S.A.
Plaza Federico Moyúa, 4 Bilbao

Sweden
Elektriska Aktiebolaget AEG
Sveavagen 21, Stockholm 1

Switzerland
Novelectric Ltd.
Claridenstrasse 25, Zurich 22

Syria
F. A. Kettaneh
Rue Movawiva, Damascus

Thailand
Kamol Sukosol Co., Ltd.
857 Mahajai Road, Bangkok

The Netherlands
Mijnssen & Co., N. V.
Keizersgracht 205, Amsterdam-C

Turkey
Koc Ticaret T.A.S.
Ulus Meydani, Ankara

Uruguay
General Electric S.A.
Defensa 1926, Montevideo

Venezuela
International General Electric, S.A., Inc.
Principal a Sta. Capilla No. 4, Caracas

West Indies-Bahamas
General Hardware Co.
Nassau, Bahamas, B.W.I.

West Indies-Barbados
Electric Sales & Service, Ltd.
Tweedside Road, St. Michael, Barbados, B.W.I.

West Indies-Jamaica
Kingston Industrial Agencies, Ltd.
1 Darling St., Kingston, Jamaica, B.W.I.

West Indies-Trinidad & Tobago
Neal & Massy Engineering Co., Ltd.
61-63 Edward St., Port-of-Spain, Trinidad, B.W.I.

Yugoslavia
New York Commodities Corp.
60 Broad St., New York, 4, N.Y., U.S.A.

INTERNATIONAL GENERAL ELECTRIC COMPANY, INC.

GENERAL ELECTRIC
IA-50-38E
NEW YORK U.S.A. SCHENECTADY

LIBRARY NOTES

ON ARTICLES IN OTHER TECHNICAL JOURNALS

ALLOYS

ELECTROGRAPHIC ANALYSIS FOR IDENTIFYING HIGH-TEMPERATURE ALLOYS, by Martin E. Levy. *Iron Age*, Aug. 18, 1949; v. 164, pp. 98-100.

Rapid detection of Cr, Ni, Co, Mo, W, Ti, and Fe in high-temperature alloys, made possible by spot tests as applied to electrographic analysis.

NEW COPPER-BASE DIE ALLOYS, by J. F. Clement. *Steel*, Sept. 5, 1949; v. 125, pp. 84-86, 124.

Describes alloys that have been used ecomomically over a wide range of work, affording longer life and freedom from galling, scratching, and die maintenance downtime.

ELECTRODES

ELECTRODE COATINGS CONTAINING RUTILE, by R. D. Van Zante and others. *Weld. Jour.*, Sept. 1949; v. 28, pp. 439s-444s.

Describes properties of weld-metal tests of experimental electrodes containing approximately 40 per cent rutile.

OPERATING CHARACTERISTICS OF ARC-WELDING ELECTRODES, by F. W. Myers, Jr. *Steel*, Sept. 19, 1949; v. 125, pp. 78-82, 84.

Incidental factors besides the human element which have considerable effect on electrode operation and cost.

GEARS

MODIFICATION OF GEAR-TOOTH PROFILES, by D. W. Dudley. *Prod. Engng.*, Sept. 1949; v. 20, pp. 126-131.

Recommended method of changing the involute profiles of heavily loaded gears to reduce noise, interference, and wear.

PLASTICS

NITRILE RUBBER-PHENOLIC BLENDS, by R. C. Bascom. *Modern Plastics*, Sept. 1949; v. 27, pp. 84-86.

A combination which makes a tougher plastic, a reinforced rubber, or a strong adhesive.

POLYETHYLENE: USES AND PROSPECTS, by Charles A. Southwick, Jr. *Modern Packaging*, Aug. 1949; v. 22, pp. 117, 121, 166, 168.

A summing up of this material's rapid progress in packaging and a look at its future.

POWER PLANTS

COMPARATIVE COSTS OF RESUPERHEATING INSTALLATIONS. *Elec. Wld.*, Sept. 10, 1949; v. 132, pp. 87-91.

Survey establishes detailed economic benefits of reheat where fuel costs, condensing water, attitude on flexibility, and complexity are not adverse.

1949 MODERN PLANT SURVEY. *Power*, Sept. 1949; v. 93, pp. 81-104.

Tables list engineering features of over 450 new utility and industrial steam plants, more than 175 hydroelectric units. Summaries spot design trends of recent record-breaking years.

RADIO ENGINEERING

STUDY OF THE EMF METHOD, by C. T. Tai. *Jour. App. Physics*, July 1949; v. 20, pp. 717-723.

Contains an investigation of the emf method to determine the input impedance of a thin biconical antenna as first suggested by Schelkunoff.

TRANSMISSION LINE CHARTS, by Herbert L. Krauss. *Elec. Engng.*, Sept. 1949; v. 68, pp. 767-774.

Presents details of the development and problems illustrating applications of the two most commonly used types of charts.

STRAINS AND STRESSES

STRESS-STRAIN RELATIONS IN THE PLASTIC RANGE FOR BIAXIAL STRESSES, by Joseph Marin. *Franklin Inst. Jour.*, Sept. 1949; v. 248, pp. 231-249.

Gives the results of an experimental investigation on thin-walled aluminum-alloy tubes subjected to combined tension and torsion.

Compact! Complete! Infinitely Variable!

- Exceptionally Small
- Adjustment Range 36:1
- Nominal Max. H.P. Output .025
- Speed to 20,000 R.P.M.
- Rotation Either Way

WRITE FOR BULLETIN 99

Metron Miniature Variable Speed Drive is the answer to a growing demand for *small, complete* units. Can be supplied with Metron Miniature gear units on either or both ends to accommodate any nominal input or output speeds. Ideal for low power applications such as indicators, recorders, computors, regulators, business machines, etc.

METRON INSTRUMENT COMPANY
448 Lincoln St. • Denver 9, Colo.

BUILT BY Metron MAKERS OF INSTRUMENTS FOR PRECISION MEASUREMENT

Only two holes in chassis.

Readily-wired lugs.

19/32" dia. 1 1/2, 2, 2 1/2 and 3" h.

10, 15, 20 and 25 watt.

Max. res. 6000, 9000, 12000 and 15000 ohms respectively.

★ **Just what the underwriters ordered! Exclusive Clarostat power resistor mounts above chassis. Takes heat out into the open. 5/8" hole clears terminals below. Fiber-glass core winding sealed in ceramic tube with cold-setting inorganic cement. A great space-saver!**

Details on request

CLAROSTAT *Controls and Resistors*
CLAROSTAT MFG. CO., INC. DOVER, N. H.

HOW INTERMIXED STEEL SHAFTS GAVE INDUSTRY A NEW METALS COMPARATOR

With the new test head for the metals-comparator, you can quickly and easily measure the depth of wearing surfaces, such as machine-tool beds.

cuts production costs . . . helps maintain high quality of product

When one day during World War II a truck driver delivered at the Ft. Wayne Works 25,000 motor shafts, mistakenly intermixed, he started G-E engineers on the development of an important new instrument for industry.

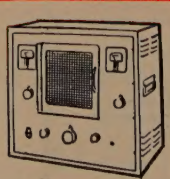
To separate the shafts, Ft. Wayne engineers rigged up an oscillator, multi-winding transformer, amplifier, and an oscilloscope, and then identified each shaft by comparing its wave pattern with the known wave patterns of the different kinds of steel used. Realizing the importance to industry of such equipment, G-E engineers developed a compact comparator for both ferrous and nonferrous metals.

Cutting Costs This instrument helps you cut costs by enabling you to separate or to identify metals quickly. For example, stock-room clerks use the instrument to separate machinable parts of cold-rolled steel from nonmachinable parts made from stainless steel. This reduces cutting-tool losses.

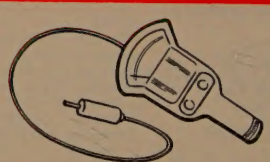
Maintaining Quality Control To help maintain the high quality of your product, use the comparator to measure the depth of case hardening, to determine changes in plating thickness, and to assure the use of specified metals.

A G-E Instrument for Your Problem G-E engineers may be able to help you solve your measuring or testing problems by recommending one of the many available G-E instruments. Your problem, if it is common to industry, may even justify developing a new instrument. Write today for information. Apparatus Department, General Electric Company, Schenectady, N. Y.

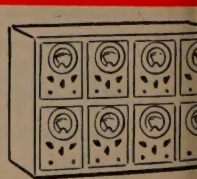
General Electric testing and measuring equipments for nearly every industrial process



Coil Testing



Time, Speed and Torque



Force, Strain and Thickness Gages